PINCKNEYVILLE AREA

Geological Science Field Trip

David L. Reinertsen and Jonathan H. Goodwin

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Department of Energy and Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY
Champaign, IL 61820

AN INTRODUCTION TO THE GEOLOGY OF THE PINCKNEYVILLE AREA

By

David L. Reinertsen and Jonathan H. Goodwin

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GEOLOGICAL SCIENCE FIELD TRIPS are free tours conducted by the Educational Extension Unit of the Illinois State Geological Survey to acquaint the public with the geology and mineral resources of Illinois. Each is an all-day excursion through one or several counties in Illinois; frequent stops are made for explorations, explanations, and collection of rocks and fossils. People of all ages and interests are welcome. The trips are especially helpful to teachers in preparing earth science units. Grade school students are welcome but each must be accompanied by a parent or guardian. High school science classes should be supervised by at least one adult for each ten students. A list of available earlier field trip guide leaflets for planning class tours and private outings may be obtained by contacting the Illinois State Geological Survey, Natural Resources Building, 615 East Peabody Drive, Champaign, IL 61820. (217) 244-2407 or 333-7372.

GEOLOGIC FRAMEWORK

Physiography and Bedrock Geology

The Pinckneyville geological science field trip area lies within Perry County in southwestern Illinois. Physiographically this area is situated in the western part of the Mt. Vernon Hill Country, the southernmost Illinois division of the Till Plains Section, Central Lowland Province (fig. 1).

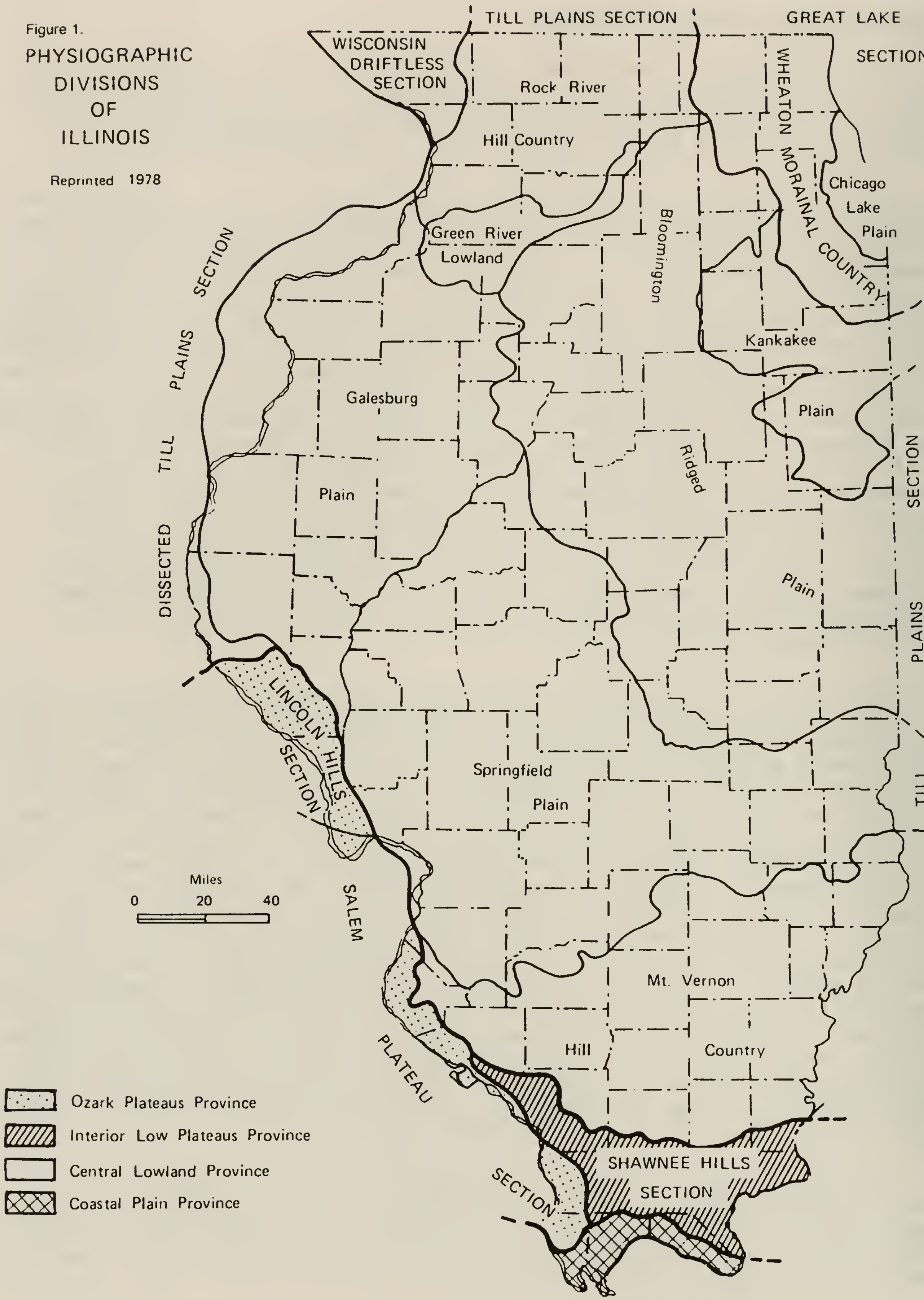
According to Horberg (1946) and others (Leighton, et al., 1948), prior to glaciation an extensive lowland called the "central Illinois peneplain" was eroded into the relatively weak rocks of Pennsylvanian age east of the present-day Illinois River. In the Perry County area, this old peneplain was a surface of low relief. A few bedrock hills that were resistant to erosion, called monadnocks, are located in the western part of the county where they rise above the general bedrock surface. The monadnocks probably are remnants of an older, higher-level erosion surface that appears to be preserved in the uplands to the west and south. Apparently, just before the advent of glaciation, an extensive system of bedrock valleys was deeply entrenched below the surface level of the central lowland. The gross features of the Till Plains Section as well as local features of the Mt. Vernon Hill Country are determined largely by this preglacial topography. As glaciation began, streams probably changed from erosion to aggradation, that is, the streams began to build up and fill in their channels because they did not have sufficient quantities of water to carry and move the increased volumes of sediment. There is no evidence to indicate that the early fills in these preglacial valleys were completely flushed out of their channels during succeeding deglaciation torrents.

During the Illinoian Stage, the southernmost advance of the continental glaciers occurred and the entire Till Plains Section was covered with ice (see PLEISTOCENE GLACIATIONS IN ILLINOIS in the appendix). The Illinoian glaciers' southernmost margin was about 41 miles southeast of Pinckneyville and some 10 miles south of Marion. The southwestern margin of this glacier reached the Mississippi River valley about 25 miles southwest of Pinckneyville. As the Illinoian glacier melted, the fine silt, sand, pebbles and boulders entrained in the ice were dropped out as the ground moraine or drift that now covers the relatively smooth, planed-off bedrock surface on which the glacier once flowed. Thus, the topography of the bedrock surface throughout much of Illinois is largely hidden from view except along the major streams. In many areas, the glacial drift is thick enough to completely mask the underlying bedrock surface. However, from studies of scattered bedrock exposures in some stream valleys and road cuts, and of mine shafts, water-well logs and other drill-hole information, we know that the Mt. Vernon Hill Country is a region in which the present land surface is largely a reflection of the underlying bedrock surface. Thus, the preglacial, low-relief bedrock surface has been only slightly modified and subdued by a thin, 20 to 30 foot, mantle of glacial drift that reaches a maximum of slightly more than 50 feet.

From the highest elevation of slightly more than 570 feet msl (mean sea level) at Mueller Hill Cemetery (Stop #1) to the lowest elevation, less than 380 feet msl, along Beaucoup Creek just south of State Route (SR) 152 between Stops 3 and 4, maximum total surface relief of the Mt. Vernon Hill Country in the field trip area is nearly 200 feet.

Figure 1.
PHYSIOGRAPHIC DIVISIONS OF ILLINOIS

Reprinted 1978



Perry County is fairly-well dissected by the south-flowing Little Muddy River and by Beaucoup and Galum Creeks and their many tributaries. The principal streams occupy preglacial bedrock valleys now filled with alluvium perhaps as much as 70 feet thick in the southern part of the county. Generally, the bedrock walls are hidden beneath glacial debris and slope-wash except where resistant bedrock strata have formed a constriction across the valley, such as along Beaucoup Creek on the northeast side of Pinckneyville. The thick alluvium in the valleys forms a fairly wide, flat bottom for the channels of these sluggish, sinuous, meandering streams.

Wind-blown silt called loess ("luss") mantles Perry County except for the valley bottoms of the larger streams. The Wisconsinan-age loess ranges from nearly six feet in southwestern Perry County to less than four feet thick in the northeast. The soils have developed in the loess and the underlying weathered Illinoian silty, clayey till. Berggren (1987) reports from his studies of the area that a substantial amount of the county's soils are not rated as "prime" farmland because of acidity, thin parent materials, low initial fertility, and excessive slopes. Furthermore, farming practices have increased erosion and caused additional fertility losses in the area.

The Precambrian crystalline basement rocks, composed of granite and granite-like igneous and metamorphic rocks lie at elevations of -6500± feet msl (more than 7000 feet below the land surface) in northwestern Perry County to -9500± feet msl (more than 9900 feet below ground) in the southeast; the distance between these two depth-to-basement measurements is about 28 miles. (Problems: What is the average slope in feet per mile of this surface? In degrees and minutes? Could you readily see this slope if you were able to view it in a 200 foot long exposure? Why, or why not?)

Treworgy (1981) reported a buried Precambrian hill about 3.5 miles west-southwest of the courthouse. This buried hill, which rises about 1000 feet or so above the deduced Precambrian surface elsewhere in this vicinity, was encountered in an oil test well in the Center NW 1/4 NW 1/4 SW 1/4 Sec. 28, T. 5 S., R. 3 W., 3rd P.M. Howard R. Schwalb (ISGS) studied the samples collected from this test well and identified formation boundaries. A skeleton log of the various systems described follows from top to bottom:

SYSTEM	TOP	BOTTOM
Quaternary	0	40
Pennsylvanian	40	840
Mississippian	840	2930
Devonian	2930	3526
Silurian	3526	3722
Ordovician	3722	6310
Cambrian	6310	6950
Precambrian	6950	7057
Total depth		7057

Bedrock strata of Pennsylvanian age occur immediately beneath the Illinoian glacial till, as noted above, and consist of shale, sandstone, siltstone, limestone, coal, and underclay that were deposited in shallow seas and swamps between about 320- and 286-million years ago (see DEPOSITIONAL HISTORY OF THE PENNSYLVANIAN ROCKS in the appendix). Thickness of Pennsylvanian strata ranges from about 400 feet in southwestern Perry County to more than 1000 feet in the eastern part of the county. Older rocks are not exposed in the field trip area.

Structurally, the Pinckneyville area is situated on the Sparta Shelf a few miles west of the DuQuoin Monocline (fig. 2). The latter marks the western boundary of the Fairfield Basin, the deepest portion of the Illinois Basin. Strata in the field trip area dip gently eastward toward the basin.

Minor structures, including the Pinckneyville Anticline (fig. 3), are evident across the Sparta Shelf. This anticline or upward fold of the rocks is asymmetrical, that is, the beds on the west flank dip considerably more steeply than those on the east. The axis of the structure (the crest of the fold) trends north-south and the apex of the anticline is east of the number 11 designating a mine shaft (fig. 3). As shown by the contours of the structure map, the axis of the anticline tilts fairly gently to the north and the fold dies out three to four miles to the north, but it plunges abruptly southward and disappears in about a mile. On the west side of the anticline is a syncline, or downwarp, that contains a faulted zone in which strata are downthrown on the east side about 28 feet. Number 9 on figure 3, between the 400- and 410-foot contours, is the location of a Pinckneyville High School foundation test boring in which the Herrin Coal, the county's major source of coal, was found at a depth of 22 feet beneath the surface.

The difference in elevation between the lowest encircling contour on the Herrin Coal and the crest of the Pinckneyville Anticline is about 60 feet. In nearby areas, where closures were less than this, productive oil and gas fields are now located. Although Mississippian Chesterian rocks yield oil in nearby structures, nothing was produced here even though there were a number of oil "shows" in nearby test wells.

The Geological Survey is embarking on a program of "Geology for Planning for Coal Mining in Perry County." According to Dwain Berggren, the ISGS geologist who is directing this research, "the purpose of this geology-for-planning study is to produce a regional geologic report providing the integrated, general information that coal mine managers need to plan, permit, and operate coal mines in the Herrin and Springfield seams; that regulators require for permit applications and review; and that governmental planners and other citizens need to anticipate the effects of coal mining. The report will be limited to a study of the units above the base of the Springfield Coal because the Murphysboro and other coals below the Springfield Coal are less likely to be mined than the shallower and better known Herrin and Springfield reserves." This study, which is envisioned as the first in a series of similar county reports, will utilize the Department of Energy and Natural Resources' (ENR) Geographic Information System (GIS) to generate project maps. The GIS is a computerized system capable of integrating information from both maps and data tables (lists) to produce new maps or data tables that portray the information in new ways to aid interpretations. For example, maps of soils, of groundwater aquifers, and of depth to bedrock might be combined

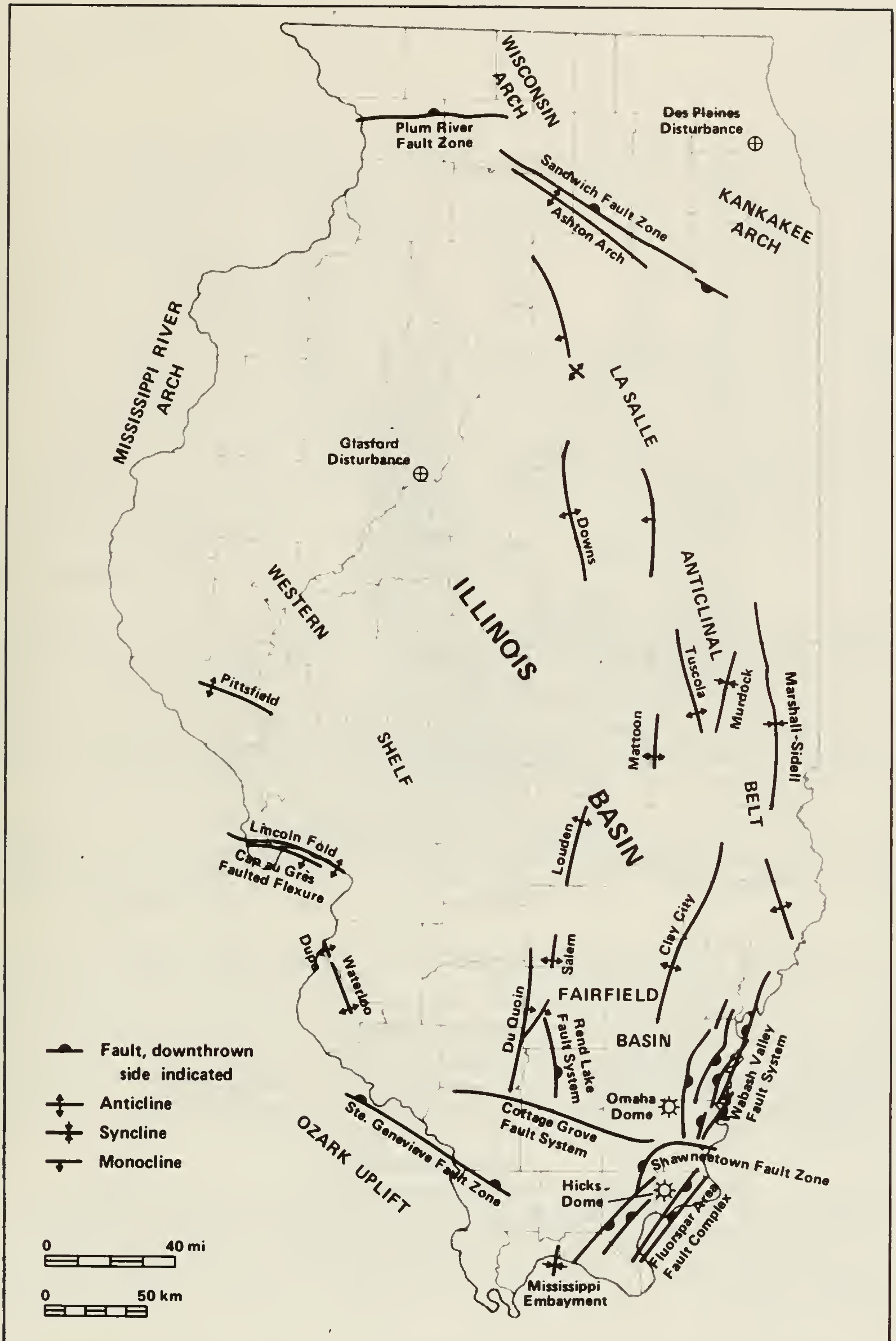


Figure 2. Major geologic structures of Illinois, compiled by Janis D. Treworgy, Dec. 1979.

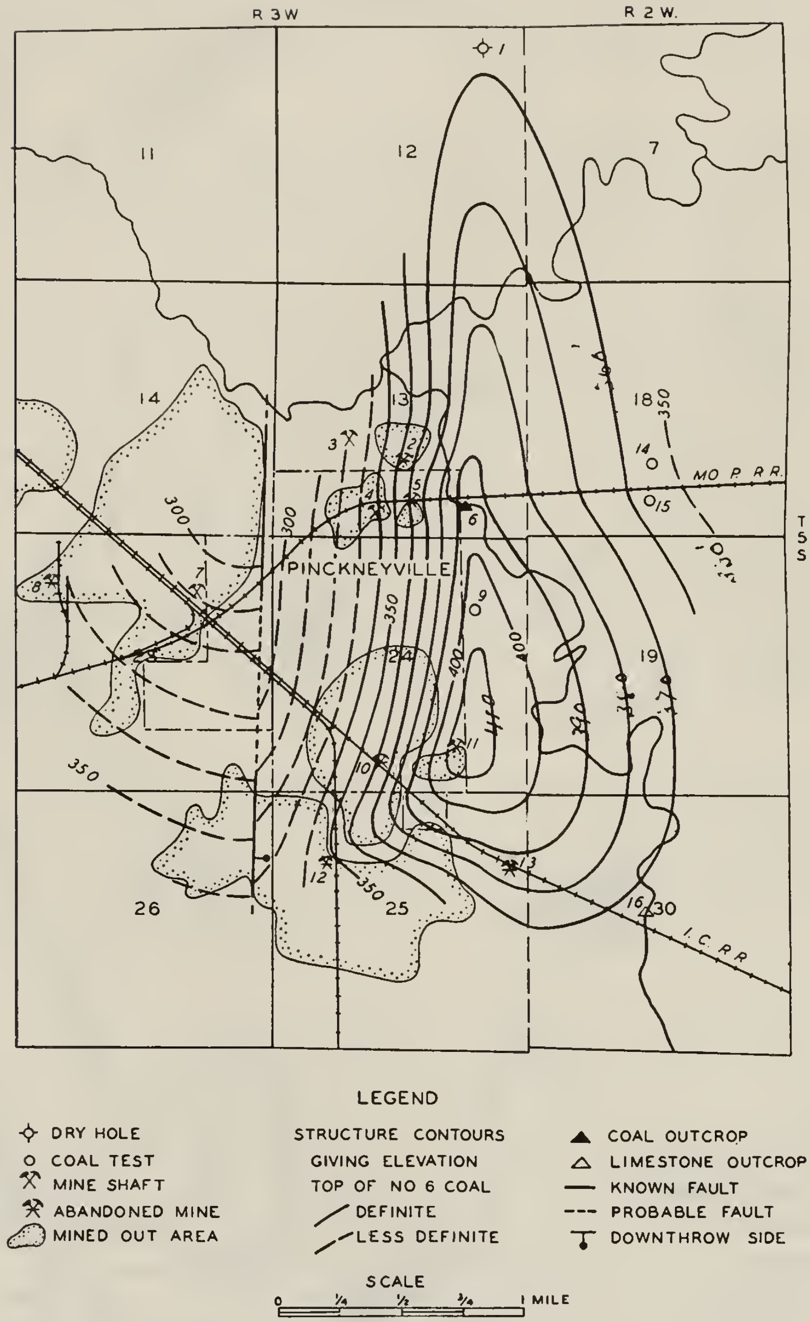


Figure 3. Structure map of the Pinckneyville area. Contour interval, 10 ft; datum, sea level (From Bell, et. al., 1931).

with other information on groundwater quality and bedrock geology to produce a new map illustrating areas that are safe, questionable, and probably unsafe for land burial of municipal wastes.

Berggren (1987) further points out that the geology, terrain, and culture favor coal mining in Perry County where both the Springfield and Herrin Coals crop out in the southern half of the county and occur at strippable depths across large areas. The vertical interval between the coals ranges from less than 10 to about 35 feet in the county, and three of the five surface mines operating in 1985 recovered both seams. In addition, one mine also recovered an average of 1.5 feet of Danville Coal that occurs a little less than 40 feet above the Herrin Coal in some parts of the county. Where mined in southwestern Perry County, the Springfield Coal is 3 to 4.5 feet thick; elsewhere it is thin or absent. The large surface mining equipment needs at least two feet of coal for support. The Herrin Coal is 5.5 to slightly more than 6 feet thick where mined, but has been reported to be as much as 8 feet thick in some areas. Coal resources for the Springfield and Herrin Coals in Perry County amounted to 2,349 million tons as of 1976 for all classification categories. Of this total, about 1.8 billion tons has a high potential for development, that is, this coal has characteristics comparable to those in presently operating mines in the area.

Mineral Production

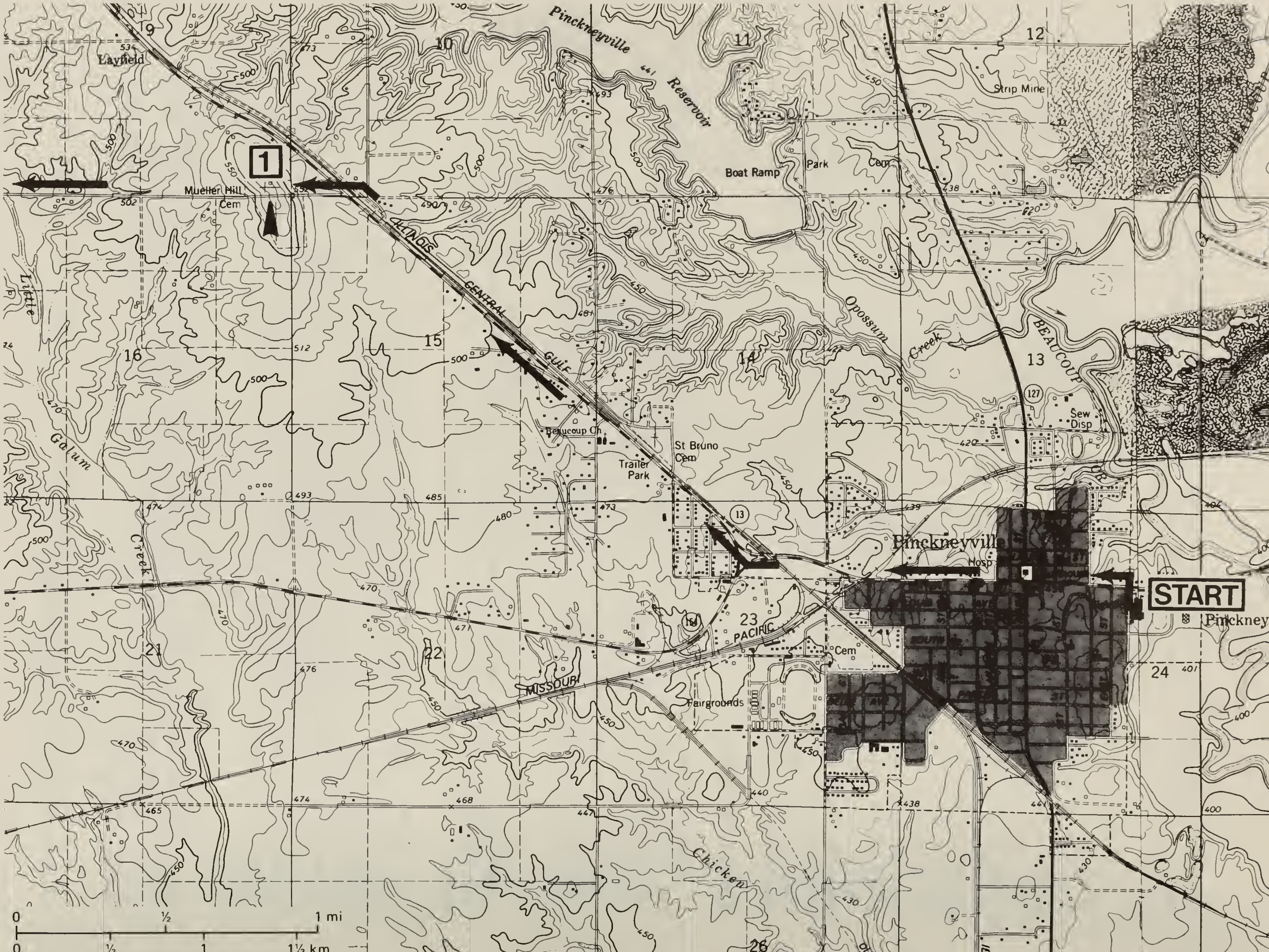
During 1984, the last year for which complete mineral production records are available, of the 102 Illinois counties, 99 reported mineral production. The total value of all minerals extracted from Illinois increased by 9.5 percent to $3.138 billion. The total value of all minerals extracted, processed, and manufactured in the state was more than $3.9 billion. Coal continued to be the leading commodity in terms of value; oil ranked second; stone and sand and gravel ranked third and fourth; fluorspar was fifth.

Nationally, Illinois ranked eighteenth in value of nonfuel mineral production. It remained the principal U.S. producer of fluorspar, tripoli, and industrial sand and led in the manufacture of iron-oxide pigments. In stone and peat production, the state ranked fourth.

Mineral resources extracted from Perry County in order of value are: coal and crude oil. Coal is obviously the more important commodity for the county's economy. Total value for these two commodities amounted to approximately $448,562,000 during 1984, which ranked the county first in total value in Illinois. Total coal production amounted to 14,995,637 tons valued at approximately $448,219,590. Crude oil production during 1984 amounted to 12,000 barrels valued at approximately $342,000. No mineral materials were processed nor were any mineral products manufactured during 1984 in Perry County.

Cumulative total production of coal from surface mines in Perry County (1833-1984) amounted to 301,356,773 tons. Cumulative total production of coal from all mines during this same time amounted to 399,171,360 tons in the county. Cumulative crude oil production in Perry County (1888-1984) amounted to 899,000 barrels.

During 1985, Perry County mines extracted 13,138,903 tons of coal; 12,526,730 tons by surface mining.


START
1
Pinckneyville
Pinckneyville Reservoir
Boat Ramp
Park
Cem
Strip Mine
Layfield
Mueller Hill Cem
ILLINOIS CENTRAL GULF
MISSOURI PACIFIC
BEAUCOUP CR
Opossum Creek
Galum Creek
Little
Chicken
Beaucoup Ch
St Bruno Cem
Trailer Park
Hosp
Sew Disp
Fairgrounds
0
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1 mi
0
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1
1½ km

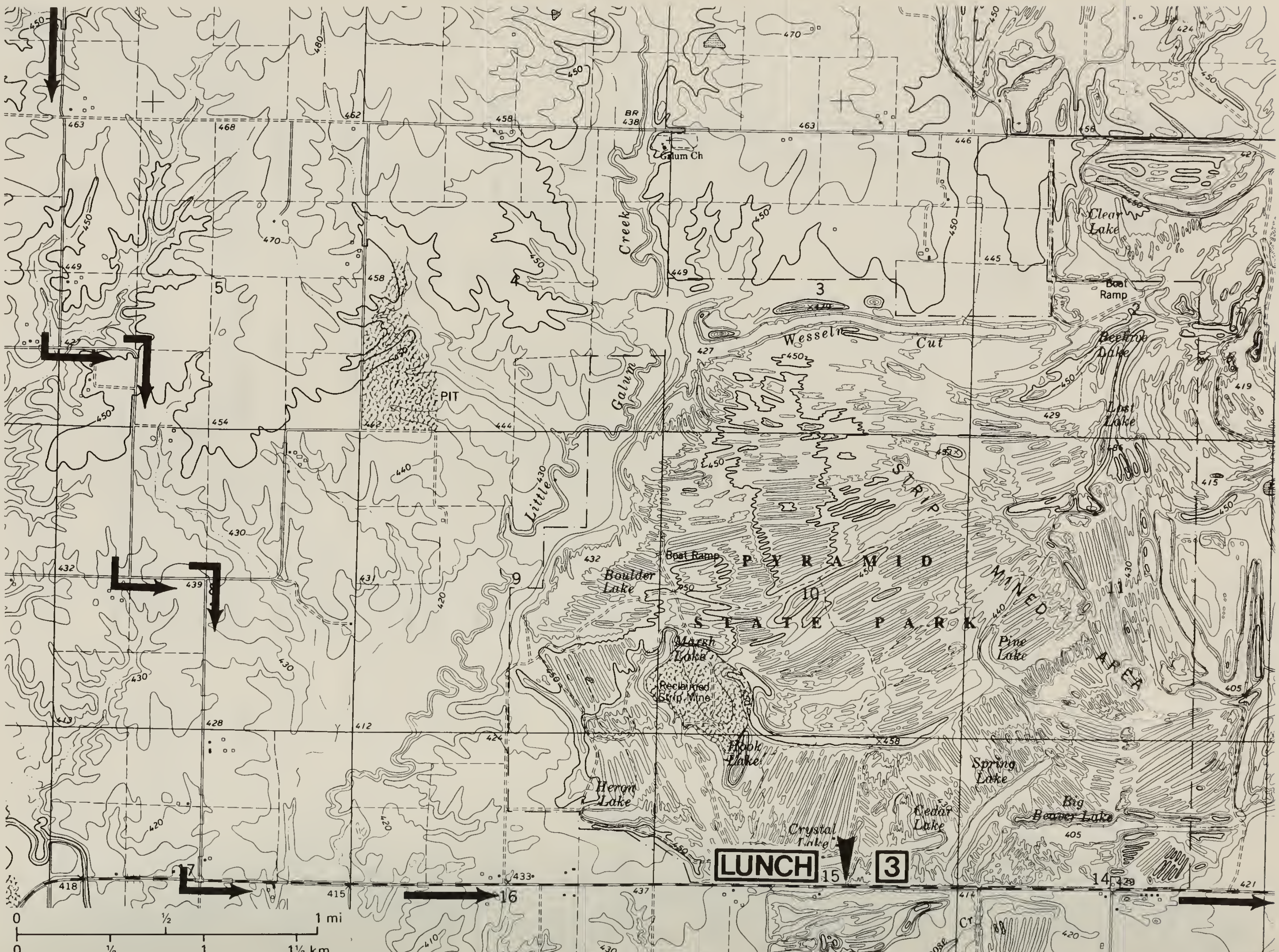
GUIDE TO THE ROUTE

Line up in the parking lot on the north side of the Thomas Gymnasium, Pinckneyville High School. This is the second building on the east side of Panther Street south of East Water Street (1/2 block south of SR 154.

Miles to next point	Miles from start	
0.0	0.0	STOP: 1-way, T-intersection with East Water Street (SR 154). TURN LEFT (west).
0.3+	0.3+	STOP: 2-way, southeast corner of the Perry County Courthouse. CONTINUE AHEAD with CAUTION on SRs 154 and 13. Opposing traffice does <u>not</u> stop.
0.05+	0.4-	STOP: 4-way, South Walnut and West Water Streets. CONTINUE AHEAD (west).
0.45+	0.85+	CAUTION: Guarded railroad crossing, single track (Union Pacific {UP}). CONTINUE AHEAD (westerly).
0.3	1.15+	Railroad underpass (Illinois Central Gulf {ICG}).
0.05	1.2+	CONTINUE AHEAD and BEAR RIGHT (northwesterly) on SR 13 toward Belleville.
1.65+	2.9	Prepare to turn left.
0.15	3.05	BEAR LEFT (west) at inverted r intersection at sign to Mueller Hill Cemetery.
0.2+	3.25+	**STOP 1.** On top of the hill at Mueller Hill Cemetery. Excellent view of the surrounding country and discussion of local topography.
0.0	3.25+	Leave Stop 1 and CONTINUE AHEAD (west).
0.9	4.15+	Concrete bridge over Little Galum Creek. Notice the broad valley.
1.0	5.15+	Notice the rather gently rolling topography in this area with some rather large, high hills. They are most likely bedrock supported. This topography will be in marked contrast to what you will see after lunch east of Pinckneyville.
1.05	6.2+	STOP: 2-way offset crossroad. TURN LEFT (south) on blacktop. Continue ascending this rather large hill.
0.6	6.8+	**STOP 2.** Pull off the road onto shoulder on the right as far as you can safely. The mobile home on the east side of the road is "Starvation Acres."

Layfield
Little Galum Creek
Hopewell Cem
MISSOURI PACIFIC
BM 475
Trinity Ch
2
16
17
18
19
20
21
28
29
30
31
32
0 ½ 1 mi
0 ½ 1 1½ km

Miles to next point	Miles from start	
		There is also a witness sign for a surveying benchmark that is on the east side of the road. Discussion of Perry County coal resources
0.0	6.8+	Leave Stop 2 and CONTINUE AHEAD (south).
0.7+	7.55-	STOP: 2-way, crossroad - State Route 154. CONTINUE AHEAD (south) on this blacktop. CAUTION: Cross traffic moves fast; visibility is a little bit restricted to the right.
0.95+	8.5	View to the right down the pit of the Horse Creek Mine #1, Arch of Illinois, Inc. The stripping wheel in the background removes the unconsolidated glacial material from the top of bedrock and stacks it behind itself to the south so that when they are leveling the spoil, it will be on top and will help form some of the upper rock free subsoil. The bedrock that holds up the bench is blasted to break it up and loosen it for easier removal by the large shovel. The wheel and the shovel travel on top of the coal so they need 2 or 3 feet of coal to support their tremendous weight. CONTINUE AHEAD (south).
0.1+	8.6+	Just to the north of this point is some of the glacial material that has been partially leveled. The large berm of material is the top soil that will be smoothed out over the leveled glacial material. Then the surface will be seeded.
0.15	8.75+	The area to the right has been reclaimed and seeded with a cover crop to control erosion.
0.3+	9.05	CAUTION: UP Railroad crossing, single track, unguarded - hamlet of Conant. CONTINUE AHEAD (south).
0.15+	9.25+	CAUTION: Crossroad. TURN LEFT (east) on to the rock road.
1.0+	10.25+	CAUTION: unguarded crossroad. TURN RIGHT (south).
1.0+	11.3	T-road from left. CONTINUE AHEAD (south) there is a little bit of a jog in the road. CONTINUE AHEAD (south) on the macadam.
0.75+	12.05+	TURN LEFT. CAUTION: There is a culvert from north to south under the road at this turn; so don't swing too wide or too short.


PYRAMID STATE PARK
STRIP MINED AREA
LUNCH
3
Wesseln Cut
Galum Creek
Little Galum
Galum Ch
PIT
Reclaimed Strip Mine
Boat Ramp
Clear Lake
Beehive Lake
Lost Lake
Boulder Lake
Marsh Lake
Hook Lake
Heron Lake
Crystal Lake
Cedar Lake
Spring Lake
Pine Lake
Big Beaver Lake
Goose Cr
0
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1 mi
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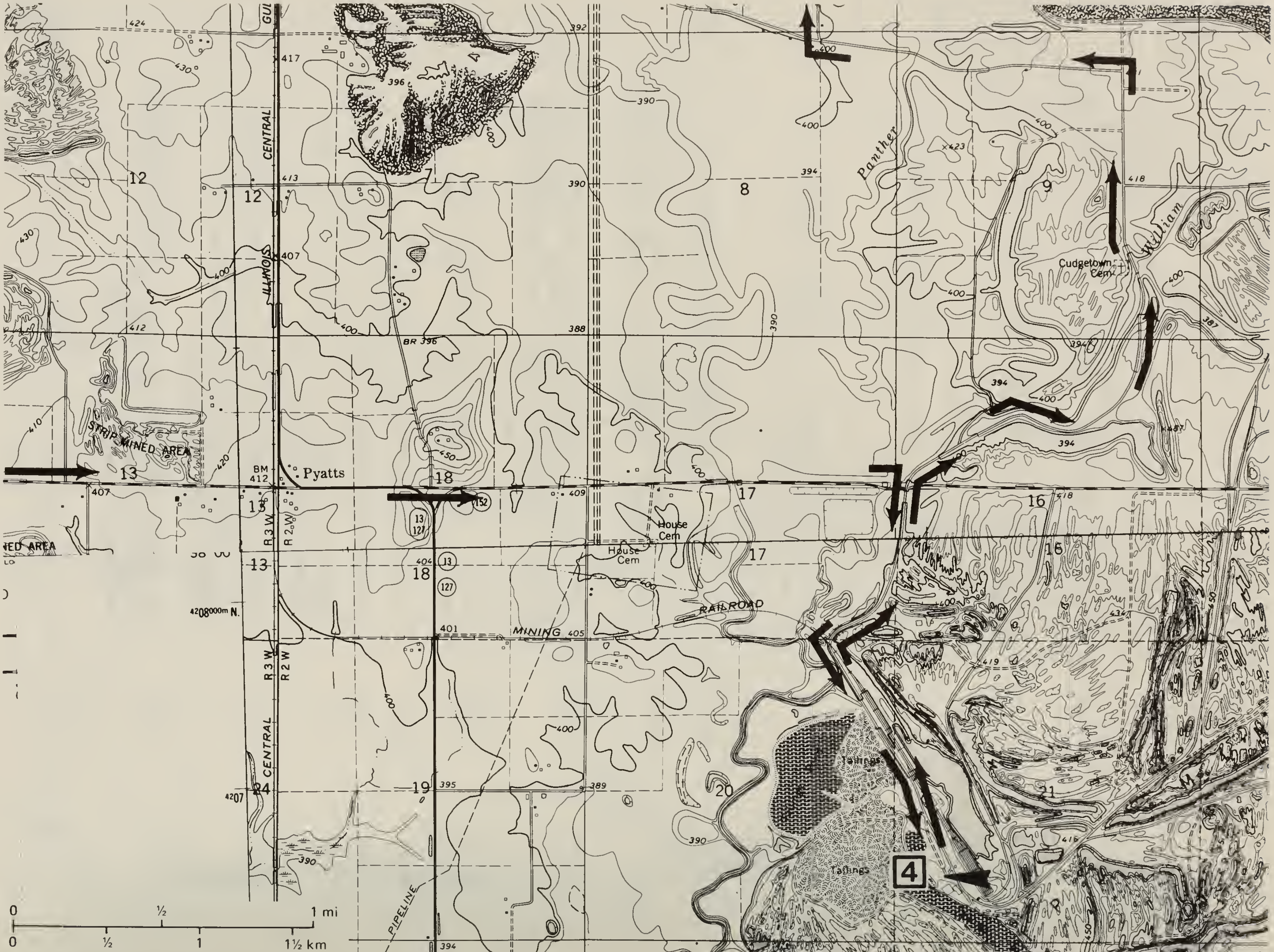
1
1½ km

Miles to next point	Miles from start	
1.0	13.05+	T-road intersection. TURN LEFT (east) on the oil and chip road.
0.25	13.3+	T-road intersection. TURN RIGHT (south) on the oil and chip road.
1.0	14.3+	STOP: 1-way - crossroad. TURN RIGHT (east) on Pyatts Road.
0.5	14.8+	Cross Little Galum Creek.
0.75	15.55+	The wooded area to the left is part of Pyramid State Park.
0.8-	16.35	Prepare to turn left.
0.1	16.45	TURN LEFT into entrance of Pyramid State Park. Resume mileage figures here after lunch.
		STOP 3. Lunch
0.0	16.45	Leave Stop 3. TURN LEFT (east) on Pyatts Road.
2.35+	18.8+	CAUTION: Rough ICG railroad crossing, single track, guarded. CONTINUE AHEAD (east) and prepare to stop.
0.05+	18.9-	STOP: 1-way. CAUTION: You are on a curve, a very dangerous area to enter the highway. Visibility to the left behind you is restricted. CONTINUE AHEAD (east) on SRs 13 and 127.
0.35+	19.25+	CONTINUE AHEAD (straight) on SR 152 at the Y-junction. USE EXTREME CAUTION in this area.
1.05	20.3+	Cross Beaucoup Creek.
0.5+	20.85	Cross Panther Creek.
0.05	20.9	TURN RIGHT (south) on an old haulage road. USE EXTREME CAUTION on this road.
0.6+	21.5+	CAUTION: entrance gate into the Freeman United Coal Company Fidelity Mine property. There is a mine railroad crossing just beyond the gate. CONTINUE AHEAD and BEAR LEFT.
0.5+	22.0+	USE EXTREME CAUTION: be alert for moving equipment in the area shop to the right. The tipple (coal preparation plant) is to the left.



Pyatts
Cudgetown Cem
House Cem
Panther
William
STRIP MINED AREA
ILLINOIS
CENTRAL
RAILROAD
MINING
PIPELINE
Tailings
4
R 3 W
R 2 W
4208000m N.
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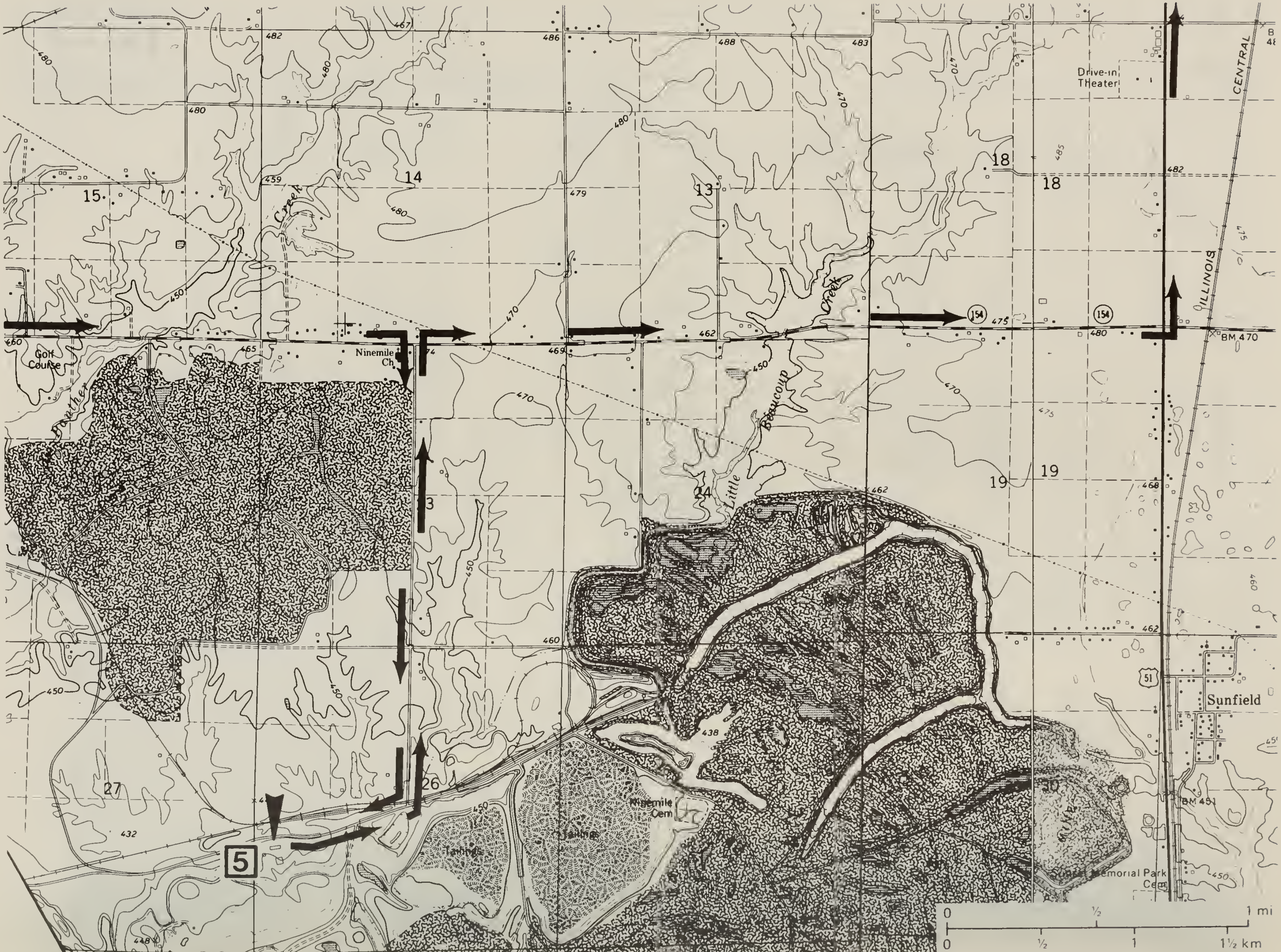
1 mi
1
1½ km

Miles to next point	Miles from start	
0.05+	22.1-	CAUTION: BEAR RIGHT around the coal piles that are straight ahead. Do NOT get close to the tipple. You will be skirting the south side of the shop area. The pink office building to the south is where you are heading.
0.05+	21.15+	Stay to the northeast of the red-roofed white building flanked by two metal buildings. Stay beyond the clump of trees but along the edge of the haulage road. BEAR RIGHT (southerly) down the lane through the marsh grass and sedges.
0.2	22.35+	TURN RIGHT (westerly) into the office parking area just north of a large silver fuel tank. You MUST have permission from this office in order to enter the property for the purpose of observing the mining operations and/or reclamation projects.
0.05	22.4+	**STOP 4.** Observation of strata above the Herrin coal, mining equipment, and some reclamation projects conducted at this surface mine.
0.0	22.4+	CAUTION: leave Stop 4 and retrace your route back to SR 152. Watch for moving equipment.
0.9	23.3+	CAUTION: Single unguarded railroad crossing. CONTINUE AHEAD (northerly) through the entrance gate.
0.6+	23.95-	STOP: 2-way - SR 152. CONTINUE AHEAD (north) on the old haulage road. USE EXTREME CAUTION in crossing the highway.
1.25	25.2+	CAUTION: Cross Williams Creek. CONTINUE AHEAD (northerly) and ascend hill.
0.3	25.5+	T-road from right. CONTINUE AHEAD (north) straight.
0.35+	25.9-	T-road from left. TURN LEFT (west).
0.4+	26.3	Notice the gently rolling topography here on the land that has not been surface mined.
0.3	26.6	Cross Panther Creek.
0.3+	26.9+	T-road from right. TURN RIGHT (north).
1.15+	28.05+	Cross creek. CONTINUE AHEAD (north).

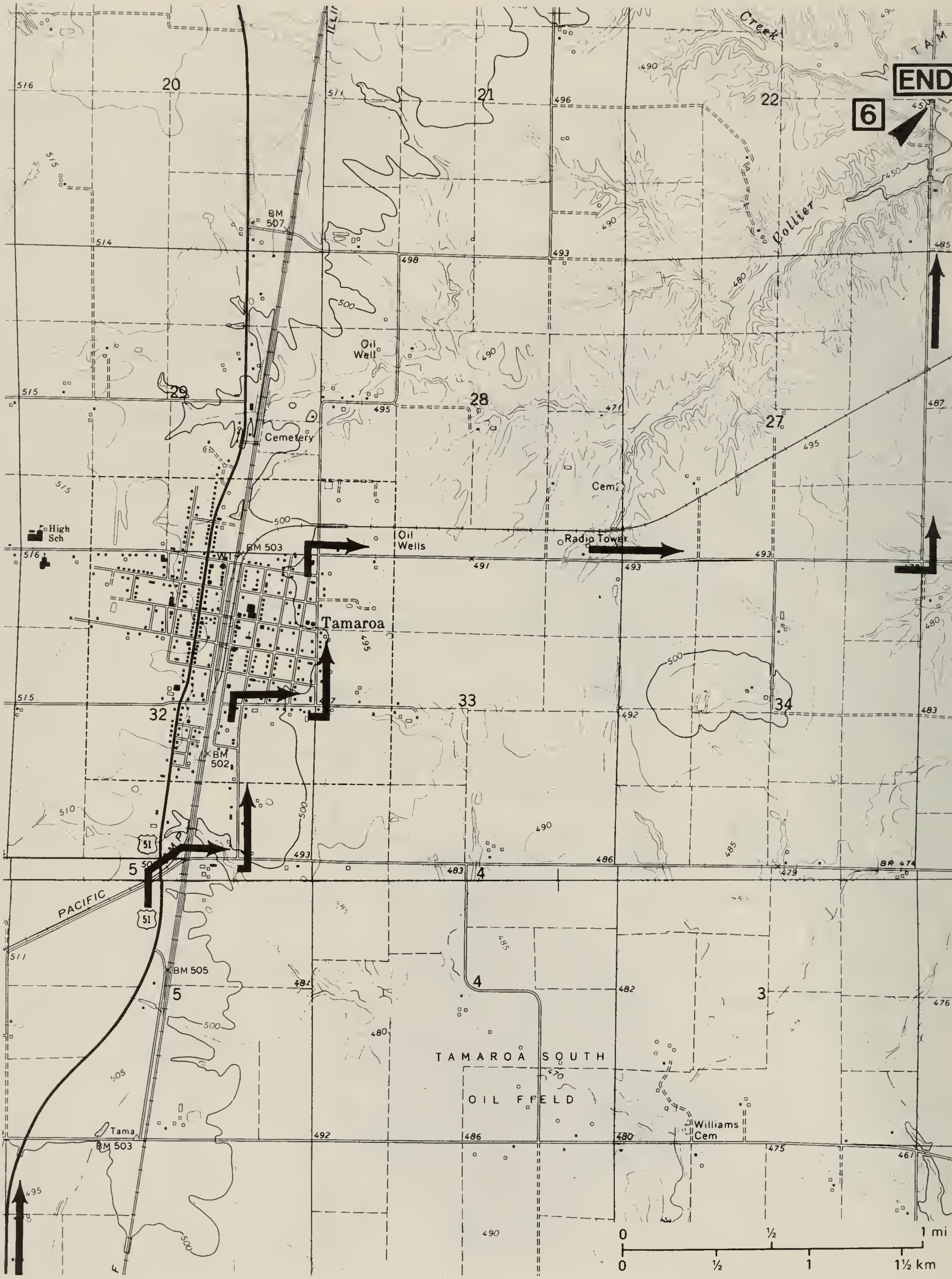
School No 204
Pick Cem
WT
Golf Course
20
21
Holts Prairie Ch
29
27
Denny
ILLINOIS
32
33
34
Dry Cem
STRIP MINED AREA
STRIP MINED AREA
4
5
PIPELINES
BR 417
BR 396
0 ½ 1 mi
0 ½ 1 1½ km

Miles to next point	Miles from start	
0.1+	28.2-	T-road from left. TURN LEFT on oil and chip road.
1.3+	29.5+	Cross pipeline.
0.05	29.55+	CAUTION: Cross creek and ascend hill curving to the right.
0.25+	29.8+	CAUTION: Single track, unguarded ICG railroad crossing. CONTINUE AHEAD (north).
0.4+	30.25+	This area has not been disturbed by mining operations. The rather flat upland surface is being cut into by the streams, producing gentle slopes along the stream valleys.
1.35+	31.6+	STOP: 2-way - crossroad. TURN RIGHT (east) on SR 154.
0.3	31.9+	Cross pipeline.
0.2	32.1+	CAUTION: Single guarded UP railroad crossing.
0.5	32.6+	To the right is one of the pits of Consolidation Coal Company Burning Star #2 Mine. A number of pieces of equipment are visible from here: a shovel, a stripping wheel, a highwall drill, and a large drag-line in the distance.
0.55	33.15+	Haulage road overpass. CONTINUE AHEAD (east).
1.05+	34.25	Cross Panther creek.
0.8	35.05	Prepare to turn right.
0.1	35.15	TURN RIGHT at T-road intersection - mine entrance road and a sign pointing to the Nine-Mile Church cemetery.
0.15	35.3	Th area to the right for the next 0.6 of a mile is a reclaimed former surface mine.
0.25	35.55	To the left at about 10:30 o'clock is the tipple for the Consolidation Coal Company Burning Star Mine #2.
0.6	36.15-	CAUTION: crossroad. CONTINUE AHEAD (south).



Drive-in Theater
CENTRAL
ILLINOIS
Golf Course
Ninemile Ch
Little Beaucoup Creek
Creek
Panther
Ninemile Cem
Sunfield
Memorial Park Cem
BM 470
BM 451
154
51
5
0 1/2 1 mi
0 1/2 1 1 1/2 km

Miles to next point	Miles from start	
0.5+	36.65+	CAUTION: single track, unguarded mine railroad crossing. TURN RIGHT (westerly) immediately after crossing the mine railroad track at the mine entrance sign. Do NOT continue ahead to the haulage road.
0.45+	37.1+	CAUTION: BEAR LEFT (southerly) around the large horizontal fuel tank.
0.05-	37.15+	CAUTION: DANGEROUS INTERSECTION with haulage road. Cross the haulage road to the large metal office building with the Consolidation Coal sign on the front.
0.05-	37.2	**STOP 5.** This is Consolidation Coal Company Burning Star #2 Mine. We will see some changes in the rocks above the Herrin Coal in two of the pits at this mine and be able to see part of this company's reclamation projects.
0.0	37.2	CAUTION: leave Stop 5 and retrace your route back to the highway (SR 154).
0.55	37.75	CAUTION: road intersection and railroad crossing. TURN LEFT (north), cross the railroad track and head north on the macadam.
0.5+	38.25+	CAUTION: crossroad. CONTINUE AHEAD (north).
0.6	38.85+	View to the upper right across the Illinois Till Plain is very good, showing you the relatively flat upland surface in this area, gently sloping up toward the north.
0.4-	39.25+	STOP: 1-way - T-road intersection with State Route 154. Turn RIGHT (east).
1.2	40.45+	Cross Little Beaucoup Creek. CONTINUE AHEAD (east).
1.25+	41.7+	STOP: 4-way. TURN LEFT (north) on U.S. 51.
2.95+	44.65+	Prepare to turn right just ahead.
0.1+	44.75+	TURN RIGHT (northeasterly) at the crossroads just before the guarded UP railroad crossing.
0.1-	44.85+	CAUTION: ICG Railroad crossing; 2-tracks guarded. CONTINUE AHEAD (east).



END
6
Creek
Collier
TAMA
20
21
22
28
27
29
32
33
34
5
4
3
BM 507
BM 503
BM 502
BM 505
Tama
BM 503
Cemetery
Oil Well
Oil Wells
Radio Tower
Cem
High Sch
Tamaroa
PACIFIC
51
TAMAROA SOUTH
OIL FIELD
Williams Cem
0
½
1 mi
0
½
1
1½ km

Miles to next point	Miles from start	
0.15+	45.0+	TURN RIGHT (north) at the T-road intersection on Locust Street in the Village of Tamaroa.
0.5+	45.55-	TURN RIGHT (east) on Third Street South.
0.2+	45.75+	T-road intersection. TURN LEFT (north) on Maple Street.
0.5-	46.25+	T-road from the right. TURN RIGHT (east) across from the American Legion Hall parking lot.
0.25	46.5+	To the right is an oil field tank battery. CONTINUE AHEAD (east).
1.65	48.15+	Prepare to turn left.
0.1	48.25+	TURN LEFT on rock road. There is a hedgerow on the west side of the road.
0.6+	48.9+	CAUTION: UP Railroad crossing; single track, unguarded.
0.65	49.55+	Cross Collier Creek.
0.2+	49.75+	Park along east road shoulder. Do not park on Eaton Creek bridge nor block the entrance to the tank battery to the southeast.

STOP 7. Discussion of Tamaroa Oil Field.

NOTE:

This is the last stop on the Pinckneyville field trip. You can either retrace the route to Tamaroa and get to U.S. 51 or you can continue ahead northwesterly for 1.25 miles to a macadam road where you turn west and southwest for 2.6+ miles to get to U.S. 51 about 1.5 miles north of Tamaroa.

FIELD TRIP STOPS

NOTE: The numbers in parentheses following the topographic map name, (42087A7), are the code assigned to that map as part of the National Mapping Program. The state is divided into 1^{0} blocks of latitude and longitude. The first pair of numbers refers to the latitude of the southeast corner of the block and the next three numbers designate the longitude. The blocks are divided into 64 7.5-minute quadrangles; the letter refers to the east-west row from the bottom and the last digit refers to the north-south row from the right.

STOP 1. Discussion of local topography from Mueller Hill Cemetery vantage point. Park as far off road as is safely possible. {Center S line SE 1/4 SE 1/4 SE 1/4 Sec. 9, T. 5 S., R. 3 W., 3rd P.M.; Pinckneyville 7.5-minute Quadrangle (38089A4)}.

Outcrop information from natural and man-made exposures, plus a wealth of data from drillholes, provided the data base for compilation of Illinois' bedrock surface map. This map indicates that bedrock at this locality is higher than 500 feet msl elevation, but somewhat less than 550 feet msl. No close-by drillhole or outcrop information are available to give a more accurate elevation figure. The surface elevation of the top of Mueller Hill is somewhat higher than 570 feet msl. Therefore, the glacial drift cover here is at least 25 to 30 feet thick; perhaps even a few feet more. Hills a couple of miles west and southwest are of comparable heights with known drift thicknesses of 20 to 30 feet.

The bedrock surface map also shows that there are no large flat buried surfaces. Instead, the bedrock surface in this area was fairly-well dissected by a network of stream valleys that had eroded their channels into bedrock, here relatively weak Pennsylvanian-age strata, before glacial drift mantled the area. The establishment and entrenchment of this stream network occurred after the central Illinois peneplain had been developed across the Pennsylvanian-age landscape but before glaciation commenced. With the onset of glaciation, conditions changed markedly across what is now Illinois. There is no known evidence to indicate that pre-Illinoian glaciers extended into this part of our state. However, when the Illinoian glaciers extended southward into northern Johnson County southeast of here, deposits were left behind to thinly mask the bedrock surface.

West and northwest of Pinckneyville the topography is very hilly with few flat upland or hilltop surfaces. With few exceptions the headward portions of the stream network are in shallow swales along the upper slopes of the hills. Down-stream the valleys widen and the streams begin to meander across the valley flats as they approach their confluence with the larger streams that flow southward across the area. This portion of the landscape can be said to be in a stage of mid-maturity because the land surface is in slopes and there is a well-developed stream network. You will have the opportunity to compare this topography with that found east of Pinckneyville later on this field trip.

STOP 2. Overview of intense surface-mining activity southwest from this vantage point and discussion of coal production in Perry County and Illinois and economic trends. {E edge SE 1/4 NE /14 NE 1/4 SE 1/4 Sec. 13, T. 5 S., R. 4 W., 3rd P.M.; Pinckneyville 7.5-minute Quadrangle (38089A4)}.

In recent years, more coal has been produced in Perry County than any other county in Illinois. In 1985, Perry County mines contributed about 13 million tons of coal valued at $405 million, some 22 percent of the state's total production of about 60.5 million tons. All but about 600,000 tons of that Perry County coal was produced from surface strip mines, and the huge drag lines, loading shovels, and other mining equipment at several of those mines are visible from this stop.

Illinois coal is used in many areas of the eastern United States for generating electricity, manufacturing coke, and other industrial activities. In 1985, the last year for which such figures are available, 89 percent of all Illinois coal was sold to electric utility generating plants, 3 percent to coke plants manufacturing metallurgical coke, and 8 percent to industrial plants. Surprisingly, only 31 percent of Illinois coal sold to electric utilities was consumed within the state. Most out-of-state sales went to Missouri, Indiana, Florida and Georgia (Samson and Bhagwat, in preparation). In recent years, coal mined in Illinois has been valued at about $2 billion annually.

Much of the coal produced in Illinois has a high sulfur content (as much as 3 to 5 percent) that makes it expensive to burn while at the same time complying with the air pollution regulations promulgated by the various states and by the U.S. Environmental Protection Agency under the Clean Air Act and its amendments. The Geological Survey has been working hard for at least the last 10 years to find ways to remove the sulfur from Illinois coal before it is burned. Two techniques we have developed have shown considerable promise in laboratory tests, but it will be some time before those technologies can be moved into the market for further development and use by industry. For now, the installation of flue gas scrubbers at electric generating plants could make it possible to continue using Illinois coal despite its high sulfur content, if the price remains competitive.

Figure 4 shows that, since 1961, the tonnage of coal mined in the U.S. has increased an average of 3.3 percent per year. Low-sulfur western coals have accounted for an increasing percentage of total U.S. coal production during the last 10 years. By 1985, the western states, especially Colorado, Montana, New Mexico, Utah and Wyoming, accounted for 30.5 percent of total U.S. production, whereas 10 years earlier they accounted for only 15.5 percent. Over the 10 year period from 1975 to 1985, coal production outside the western states increased by about 13 percent (a total of 70 million tons) while production in the western states ballooned from 100 million tons in 1975 to 270 million tons in 1985. Figure 4 also shows that total production of coal from the Illinois Basin coal states (Illinois, Indiana and western Kentucky) for the period 1975-1985 remained almost constant at 120 to 140 million tons annually. The implication of these stagnant production levels is that Illinois Basin coal is losing its market position relative to other states; the region has not participated at all in the production increases of the last 10 years (Bhagwat, 1987, p. 3-4).

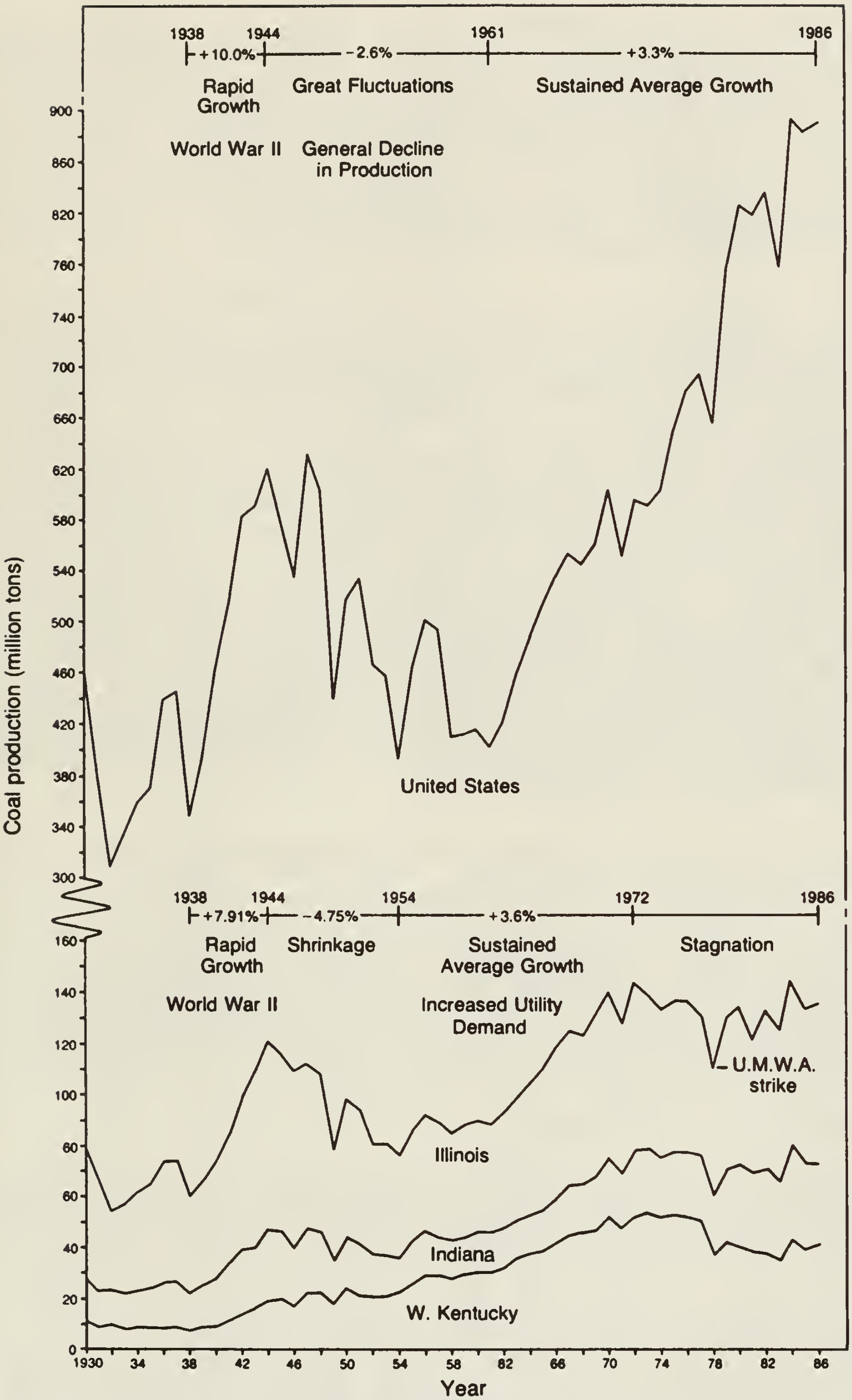


Figure 4. Trends in U.S. and Illinois Basin coal production, 1930–1986 (data adapted from U.S. Dept. of Energy, Bituminous Coal and Lignite Distribution). (from Bhagwat, 1987)

Subhash Bhagwat, Mineral Economist for the Illinois State Geological Survey, has shown that high production and delivery costs have hurt the marketability of Illinois Basin coal in recent years. When considered on the basis of delivered costs of heating value units ($/British thermal unit) some western coals, despite their lower heating values, cost about the same as coal from the Illinois Basin with higher heating value. Therefore, it is clear that reducing the sulfur content of Illinois Basin coal will not automatically ensure future sales in a highly cost-competitive market. Production costs also must be reduced (Bhagwat, 1987, p. 14-16).

Many western coal seams are incredibly thick. Surface mines near Gillette, Wyoming, for example, produce from a coal bed that is more than 100 feet thick. These mining conditions contribute to average labor productivity rates (tons mined/person/hour worked) in some western states that are 4 to 6 times greater than the average in Illinois (Bhagwat, 1987, p. 14). It should be borne in mind that most western coal is surface mined, whereas 64 percent of Illinois coal comes from underground mines. This fact contributes to the unfavorable comparisons with respect to labor productivity, since underground mining is inherently more labor intensive than surface mining. Illinois' surface minable coal resources are fairly limited in comparison to its deep minable resources. In the future, therefore, more and more coal will have to be mined underground in order to maintain the same annual production levels in Illinois. Perry County's minable coal resources having a high potential for surface mine development are estimated to be about 500 million tons or more, sufficient for about 35 to 40 more years of production at current rates. Thereafter, production will have to shift to underground mining of Perry County's estimated deep minable coal resources of 1.2 billion tons which have a high potential for development.

When a large enough area collapses in an underground coal mine, the land surface above the mine also subsides. Traditional room and pillar underground coal mining methods leave 40 to 60 percent of the available coal resource in the ground as supporting pillars to prevent the mine opening from ever collapsing. In fact, pillars sometimes do fail. In other cases, rather than failing, the weight of overlying rocks may push the pillar into the mine floor as relatively soft claystones that underlie the coal squeeze laterally out from under the pillar and into the adjacent vacant room areas. Thus, the room and pillar mining method, as presently practiced, does not infallibly prevent surface subsidence and, when used under undeveloped land areas, is unnecessarily wasteful of coal resources.

Unplanned subsidence of abandoned or inactive parts of room and pillar underground mines may damage homes and other structures and can form closed depressions that pond water in farm fields and reduce crop yields. With the cooperation of the Illinois Farm Bureau and the Illinois Coal Association, and with funds from the Illinois Coal Development Board, the U.S. Bureau of Mines and the U.S. Office of Surface Mining, the State Geological Survey is coordinating the Illinois Mine Subsidence Research Program. The twin goals of the research program are to develop mining procedures and guidelines that will allow Illinois mining companies to: 1) better design room and pillar mines where they must be used to prevent surface subsidence, and 2) increase the efficiency of underground mining through the use of mechanized longwall or high-extraction retreat mining methods that substantially increase the amount of coal that is ultimately removed from the ground. High-extraction mining removes virtually all of the coal from the ground and allows the land surface to subside as the mine opening closes. Preliminary results of the ISGS-led program indicate that crop yields on farm land above high-extraction mined areas are reduced approximately 3 to 7 percent before taking any remedial measures. These effects seem to be small enough to be overcome by relatively inexpensive drainage improvements or land regrading, but studies of various mitigation techniques are only just beginning. It is expected that ways will be found for two of Illinois' major industries, coal mining and farming, to coexist harmoniously. As shown by the recent market trends, improved efficiency of underground mining is essential if the Illinois coal mining industry is to remain competitive.

STOP 3. Lunch at Pyramid State Park. {Entrance: north side of Pyatts Road, SW cor SE 1/4 SW 1/4 NE 1/4 Sec. 15, T. 6 S., R. 3 W., 3rd P.M.; Pinckneyville 7.5-minute Quadrangle (38089A4)}.

Pyramid State Park, which is located about six miles south-southwest of Pinckneyville, is the site of part of a former strip mine known as the Pyramid Mine, which was operated by Truax-Traer Coal Company. This company became an operating division of Consolidation Coal Company during the late 1960s.

This heavily wooded area consists of more than 2500 acres of numerous ridges and lakes left behind by the mining operations from 1930 to 1950. More than 135 acres of water occur in lakes and ponds ranging in size from .01 to 24 acres. A stand of mature hardwoods, mostly white oak and hickory, is on an undisturbed tract of land along the west side of the park. The most common reclamation program used by mines during the 1930s was tree planting. However, this was gradually phased out largely because the economic return from the program was too slow to realize.

The State of Illinois began acquiring acreage here in 1965.

MINING

STOP 4. Visit to Freeman United Coal Company Fidelity Mine to observe bedrock strata above the Herrin Coal, mining equipment, and reclamation projects. Mine office: SE 1/4 SW 1/4 NW 1/4 SW 1/4 Sec. 21, T. 6 S., R. 2 W., 3rd P.M.; Vergennes 7.5-minute Quadrangle (37089H3) .

Freeman United Coal Mining Company's Fidelity No. 11 Mine, which opened in 1929, is the oldest working surface mine in Illinois. During the late 1930s, this mine operated three pits which had an annual output of 1.2 million tons, a world production record. During 1985, the mine produced more than 800,000 tons of Herrin Coal. Total production from the mine through 1985 has amounted to nearly 73.9 million tons of coal.

Fidelity mine has used electric power shovels to uncover the coal since its opening. As more modern and larger pieces of equipment were developed, Fidelity acquired them when needed to meet its goals. Wheel excavators, used for removal of unconsolidated overburden material, were designed and developed by company engineers beginning in 1955.

Bulldozers prepare land for surface mining by removing trees. Scrapers then stockpile the topsoil for later reclamation work. The huge bucket-wheel excavator moves across the exposed coal bench left by the large shovel and produces a bench on top of bedrock as it removes the remaining subsoil and glacial materials. The unconsolidated materials are moved along the conveyor-belt stacker on the back of the machine and dumped on top of previously piled broken bedrock left by the shovel. Once the wheel excavator has produced a bench on top of bedrock, a highwall drill places holes along the bench in order to blast and break up the bedrock so that it can be more readily removed by the large shovel. Smaller loading shovels load exposed coal into special, large off-highway haulage trucks that carry it to the preparation plant where it is washed, sized, and made ready for shipment. More than 557 thousand tons of prepared coal were shipped by rail (ICG) during 1985; 204 thousand+ tons were shipped by rail and barge; nearly 67 thousand tons were shipped via truck; and more than 800 tons were sold to the local trade.

Reclamation of mined lands began at the Fidelity No. 11 Mine during the 1930s when the mine cooperated with the Illinois Forestry Division in a statewide effort to plant equal acreages of trees for acreages mined by surface mines. Stands of black locust and short-leaf pine were first planted when much of the early planting was done directly on the spoil piles with little or no leveling being done prior to the planting. When World War II brought an end to the state program, Fidelity managers decided to do their own reclamation program because they wanted outsiders to know that mined lands were <u>not</u> waste lands. In addition to the early tree plantings, an orchard was established and Fidelity Farms marketed apples and peaches under the "Black Diamond Brand" throughout the U.S. and Canada. In addition, a large herd of cattle was grazed on reclaimed land.

By the time reclamation laws were first enacted in 1961, Fidelity had made a large effort on its own. The laws have become stiffer in recent years. Partly because of this, and partly because of various economies of operation, more acreage is being returned to farmland status consisting of grasses, legumes, and more recently row crops. The wheel excavator has enabled the mine to carry out its reclamation effort more easily in that the subsoil materials are mixed as they are transported off of the stacker belt and moved about by the bulldozers and scrapers in the leveling operation. The topsoil can then be spread over the leveled subsoil materials placing the ground back close to its original contour and productivity. Many variables must be taken into account when reclaiming an area. What was the original configuration of the land; what was its fertility; how was it used; what farming practices were employed; etc.? In reclaiming the land, consideration must also be given as to the best use of the land under its given geographical, geological, and meteorological conditions.

The following stratigraphic section, which was compiled by Russell Jacobson of the Geological Survey several years ago, shows the general order of the bedrock strata exposed in this vicinity:

QUATERNARY SYSTEM
  Pleistocene Series
    Illinoian Stage
      Liman Substage
        Glasford Formation

Till - medium orange mottled greenish, clayey, massive, well jointed; 10 - 40 feet.

PENNSYLVANIAN SYSTEM
Desmoinesian Series
Kewanee Group
Carbondale Formation
unnamed - clay shale - medium green to whitish, weathered, soft, blocky, calcareous with abundant small calcareous nodules, sharp basal contact; 1 - 15 feet.
Bankston Fork Limestone Member - medium greenish gray to orange yellow, argillaceous, massive, hard, well jointed, fairly fossiliferous (brachiopods, crinoid fragments, and algal? remains, 7.6 feet.
unnamed - shale-medium to dark gray with mottles of green to yellow orange where weathered, thin bedded, finely micaceous, non-calcareous, unconformable top and bottom contacts, silty, clayey, 6.5 feet.
unnamed - siltstone to fine sandstone-medium gray with abundant thin discontinuous dark carbonaceous ripple drift laminae throughout, finely micaceous, very hard, calcareous, 2.0 feet.
Conant Limestone Member - medium gray, argillaceous, massive hard, dense, fairly fossiliferous (brachiopods, crinoid columnals, etc., has several prominent white calcite-coated vertical joints, 4.8 feet.
unnamed - shale-medium to dark gray, thin bedded, very calcareous, finely micaceous, fairly fossiliferous, 2.3 feet.
unnamed - shale-medium dark to black gray, very carbonaceous thin bedded, slaty, non-calcareous, contains thin vitrain laminations throughout, 1 foot, grades down to:
Jamestown Coal Member - normally bright and banded, has a coaly 1/2 inch shale band 0.1 foot above base, 0.5 foot.
unnamed - limestone-medium to dark gray, nodular, argillaceous, not present everywhere, very fossiliferous throughout, 0.1 foot.
unnamed - shale-medium dark gray, semi-slaty bedding, fairly carbonaceous throughout, non-calcareous, finely micaceous, contains pyritized and carbonaceous root fragments (Stigmaria), 0.3 foot.
Brereton Limestone Member - medium to dark gray, argillaceous, hard, massive but does contain some irregular shaley partings that give the stone a semi-nodular appearance in places, moderately to abundantly fossiliferous throughout, 9.2 feet.
Anna Shale Member - black, slaty, very carbonaceous, finely micaceous, hard and brittle, 2.0 feet.
Herrin (No. 6) Coal Member - normally bright and banded, blocky, with calcite and pyrite on vertical cleats, dark gray "Blue Band" shale (0.10 foot thick, 0.87 foot above base), 6.36 feet.
unnamed - claystone-dark olive gray, mottled, carbonaceous, floor.

These are the essential elements in the stratigraphic sequence in this area; thicknesses may change; some units may disappear; others may appear.

STOP 5. Visit to Consolidation Coal Company Burning Star No. 2 Mine to observe Herrin Coal overburden, mining equipment, and reclamation projects. {Mine office: N 1/2 SW 1/4 NW 1/4 SW 1/4 Sec. 26, T. 5 S. R. 2 W., 3rd P.M.; Pyatts 7.5-minute Quadrangle (38089A3)}.

The Consolidation Coal Company Burning Star No. 2 Mine began producing coal in 1950. During 1985, this mine produced more than 1.67 million tons of coal from the Herrin Coal Member of the Carbondale Formation. The coal averages 6 feet thick and is overlain by about 110 feet of overburden. This mine shipped nearly 1.62 million tons by UP rail; almost 45,000 tons by truck. More than 1,400 tons were sold to the local trade. Total production for No. 2 Mine since it opened has amounted to more than 49.4 million tons of coal.

The operating pit of the mine, just northeast of Pinckneyville, uses a huge dragline to remove the thick bedrock overburden above the coal. Scrapers remove the topsoil and unconsolidated materials so that they may be stockpiled and then used in the reclamation projects in the area. Rather extensive acreages have been seeded to control erosion and to add organic materials to the newly forming soils.

The following generalized stratigraphic section is adapted from one that was compiled by Russell Jacobson of the Coal Section, Illinois State Geological Survey, several years ago from an active pit just south of SR 154:

QUATERNARY SYSTEM
- Pleistocene Series
  - Illinoian Stage
    - Liman Substage
      - Glasford Formation
        - Till - yellow to orange, clayey, massive appearance, 10 to 40 feet.

PENNSYLVANIAN SYSTEM
- Desmoinesian Series
  - McLeansboro Group
    - Modesto Formation
      - unnamed - shale-variegated red, green and gray, weathered, thin bedded, well jointed, 5 - 10 feet.
      - Piasa Limestone Member - reddish brown, fine grained, massive, well jointed, weathered, 10 feet.
  - Kewanee Group
    - Carbondale Formation
      - Danville (No. 7) Coal Member - smutty, thin to 2 feet.
      - unnamed - claystone-dark greenish gray, massive, 2 feet.
      - unnamed - clayshale-greenish to greenish gray, massive to thinly bedded, 8 feet.
      - Bankston Fork Limestone Member - light gray to tan, massive, 3 - 6 feet.
      - unnamed - shale-light gray, well bedded, 2 - 3 feet.
      - unnamed shale-dark to medium gray, 4 feet.
      - Conant Limestone Member - medium gray, massive, very argillaceous, 2 feet.

unnamed shale - dark gray, calcareous, 2 feet.
Jamestown Coal Member - normally bright banded, 2 - 7 inches.
unnamed limestone - dark gray, argillaceous, nodular, 7 inches.
unnamed shale - dark gray, calcareous, 4 feet.
Brereton Limestone Member - dark to medium gray, argillaceous, hard, 2 - 4 feet.
Anna Shale Member - black, silty, 2 - 3 feet.
Herrin (No. 6) Coal Member - normally bright banded, 4 - 5 feet.

An abandoned pit a couple of miles northwest of the above section and north of SR 154, indicates that the glacial till is 20 - 40 feet thick immediately over the Bankston Fork Limestone; the upper part of the Pennsylvanian section is missing there. The interval from the Bankston Fork Limestone to the Brereton Limestone is slightly thinner and the Conant Limestone is missing. The present operating pit northeast of Pinckneyville contains additional units that overlie the Piasa Limestone in the longer section above.

STOP 6. Discussion and view of part of the Tamaroa Oil Field. {Park along roadside: W edge NW 1/4 NW 1/4 NW 1/4 SW 1/4 Sec. 23, T. 4 S., R. 1 W., 3rd P.M.; Tamaroa 7.5-minute Quadrangle (38089B2)}.

Richard Howard from the Oil and Gas Section of the Geological Survey states that the Tamaroa Oil Field was discovered in 1942 when a well was completed in the Mississippian (Chesterian) Cypress Sandstone (personal communication). In 1964, the Ordovician Trenton Limestone (Galena Group) began to produce in this field. The well east of the road is producing from the Trenton. These reservoirs occur in an asymmetrical dome that is elongated roughly northeast - southwest and is steeper on the southeast side facing the Fairfield Basin. The depth to the Cypress reservoir is about 1,100 feet and to the Trenton about 4,100 feet.

Nearly 500,000 barrels of crude oil has been produced from the Tamaroa Oil Field, of which 150,000 barrels has resulted from secondary recovery methods (waterflooding).

Figure 5 shows a common type of oil production unit in Illinois.

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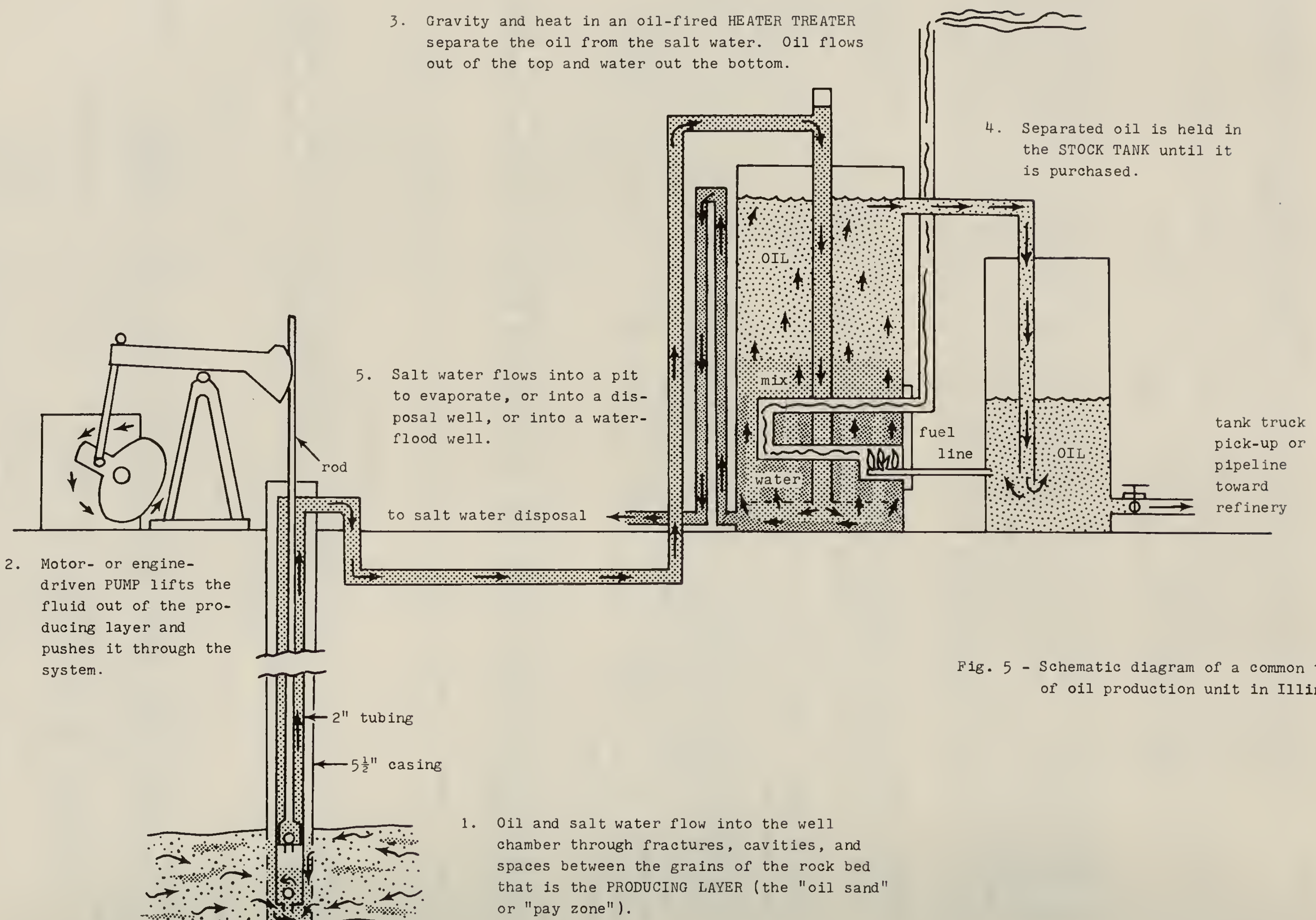

Fig. 5 - Schematic diagram of a common type of oil production unit in Illinois.

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DEPOSITIONAL HISTORY OF THE PENNSYLVANIAN ROCKS

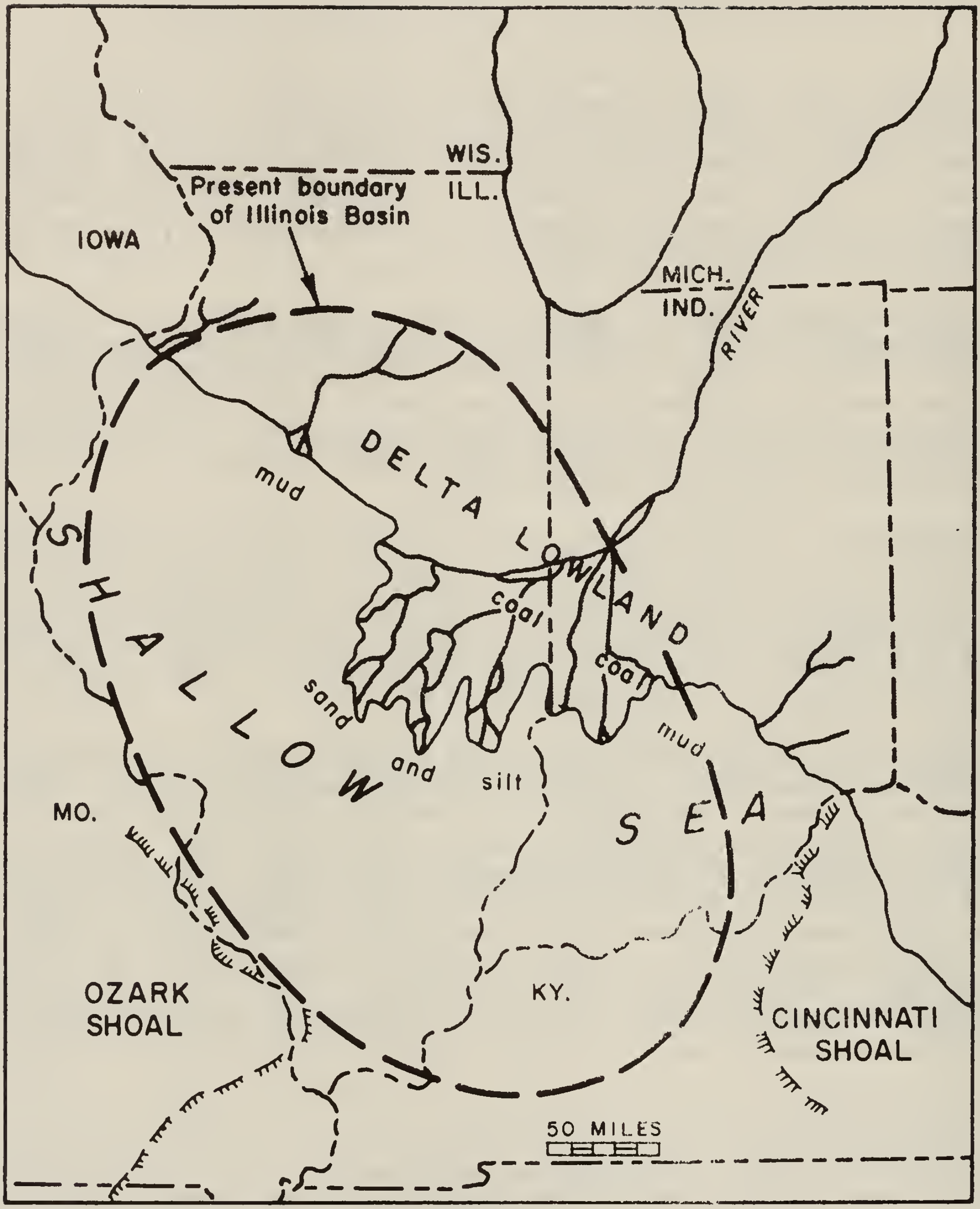
At the close of the Mississippian Period, about 310 million years ago, the Mississippian sea withdrew from the Midcontinent region. A long interval of erosion took place early in Pennsylvanian time and removed hundreds of feet of the pre-Pennsylvanian strata, completely stripping them away and cutting into older rocks over large areas of the Midwest. An ancient river system cut deep channels into the bedrock surface. Erosion was interrupted by the invasion of the Morrowan (early Pennsylvanian) sea.

Depositional conditions in the Illinois Basin during the Pennsylvanian Period were somewhat similar to those that existed during Chesterian (late Mississippian) time. A river system flowed southwestward across a swampy lowland, carrying mud and sand from highlands in the northeast. A great delta was built out into the shallow sea (see paleogeography map on next page). As the lowland stood only a few feet above sea level, only slight changes in relative sea level caused great shifts in the position of the shoreline.

Throughout Pennsylvanian time the Illinois Basin continued to subside while the delta front shifted owing to worldwide sea level changes, intermittent subsidence of the basin, and variations in the amounts of sediment carried seaward from the land. These alternations between marine and nonmarine conditions were more frequent than those during pre-Pennsylvanian time, and they produced striking lithologic variations in the Pennsylvanian rocks.

Conditions at various places on the shallow sea floor favored the deposition of sandstone, limestone, or shale. Sandstone was deposited near the mouths of distributary channels. These sands were reworked by waves and spread as thin sheets near the shore. The shales were deposited in quiet-water areas—in delta bays between distributaries, in lagoons behind barrier bars, and in deeper water beyond the nearshore zone of sand deposition. Most sediments now recognized as limestones, which are formed from the accumulation of limey parts of plants and animals, were laid down in areas where only minor amounts of sand and mud were being deposited. Therefore, the areas of sandstone, shale, and limestone deposition continually changed as the position of the shoreline changed and as the delta distributaries extended seaward or shifted their positions laterally along the shore.

Nonmarine sandstones, shales, and limestones were deposited on the deltaic lowland bordering the sea. The nonmarine sandstones were deposited in distributary channels, in river channels, and on the broad floodplains of the rivers. Some sand bodies, 100 or more feet thick, were deposited in channels that cut through many of the underlying rock units. The shales were deposited mainly on floodplains. Freshwater limestones and some shales were deposited locally in fresh-water lakes and swamps. The coals were formed by the accumulation of plant material, usually where it grew, beneath the quiet waters of extensive swamps that prevailed for long intervals on the emergent delta lowland. Lush forest vegetation, which thrived in the warm, moist Pennsylvanian climate, covered the region. The origin of the underclays beneath the coals is not precisely known, but they were probably deposited in the swamps as slackwater muds before the formation of the coals. Many underclays contain plant roots and rootlets that appear to be in their original places. The formation of coal marked the end of the nonmarine portion of the depositional cycle, for resubmergence of the borderlands by the sea interrupted nonmarine deposition, and marine sediments were then laid down over the coal.



Paleogeography of Illinois-Indiana region during Pennsylvanian time. The diagram shows the Pennsylvanian river delta and the position of the shoreline and the sea at an instant of time during the Pennsylvanian Period.

Pennsylvanian Cyclothems

Because of the extremely varied environmental conditions under which they formed, the Pennsylvanian strata exhibit extraordinary variations in thickness and composition, both laterally and vertically. Individual sedimentary units are often only a few inches thick and rarely exceed 30 feet thick. Sandstones and shales commonly grade laterally into each other, and shales sometimes interfinger and grade into limestones and coals. The underclays, coals, black shales, and limestones, however, display remarkable lateral continuity for such thin units (usually only a few feet thick). Coal seams have been traced in mines, outcrops, and subsurface drill records over areas comprising several states.

The rapid and frequent changes in depositional environments during Pennsylvanian time produced regular or cyclical alternations of sandstone, shale, limestone, and coal in response to the shifting front of the delta lowland. Each series of alternations, called a cyclothem, consists of several marine and non-marine rock units that record a complete cycle of marine invasion and retreat. Geologists have determined, after extensive studies of the Pennsylvanian strata in the Midwest, that an ideally complete cyclothem consists of 10 sedimentary units. The chart on the next page shows the arrangement. Approximately 50 cyclothems have been described in the Illinois Basin, but only a few contain all 10 units. Usually one or more are missing because conditions of deposition were more varied than indicated by the ideal cyclothem. However, the order of units in each cyclothem is almost always the same. A typical cyclothem includes a basal sandstone overlain by an underclay, coal, black sheety shale, marine limestone, and gray marine shale. In general, the sandstone-underclay-coal portion (the lower 5 units) of each cyclothem is nonmarine and was deposited on the coastal lowlands from which the sea had withdrawn. However, some of the sandstones are entirely or partly marine. The units above the coal are marine sediments and were deposited when the sea advanced over the delta lowland.

Origin of Coal

It is generally accepted that the Pennsylvanian coals originated by the accumulation of vegetable matter, usually in place, beneath the waters of extensive, shallow, fresh-to-brackish swamps. They represent the last-formed deposits of the nonmarine portions of the cyclothems. The swamps occupied vast areas of the deltaic coastal lowland, which bordered the shallow Pennsylvanian sea. A luxuriant growth of forest plants, many quite different from the plants of today, flourished in the warm Pennsylvanian climate. Today's common deciduous trees were not present, and the flowering plants had not yet evolved. Instead, the jungle-like forests were dominated by giant ancestors of present-day club mosses, horsetails, ferns, conifers, and cycads. The undergrowth also was well developed, consisting of many ferns, fernlike plants, and small club mosses. Most of the plant fossils found in the coals and associated sedimentary rocks show no annual growth rings, suggesting rapid growth rates and lack of seasonal variations in the climate. Many of the Pennsylvanian plants, such as the seed ferns, eventually became extinct.

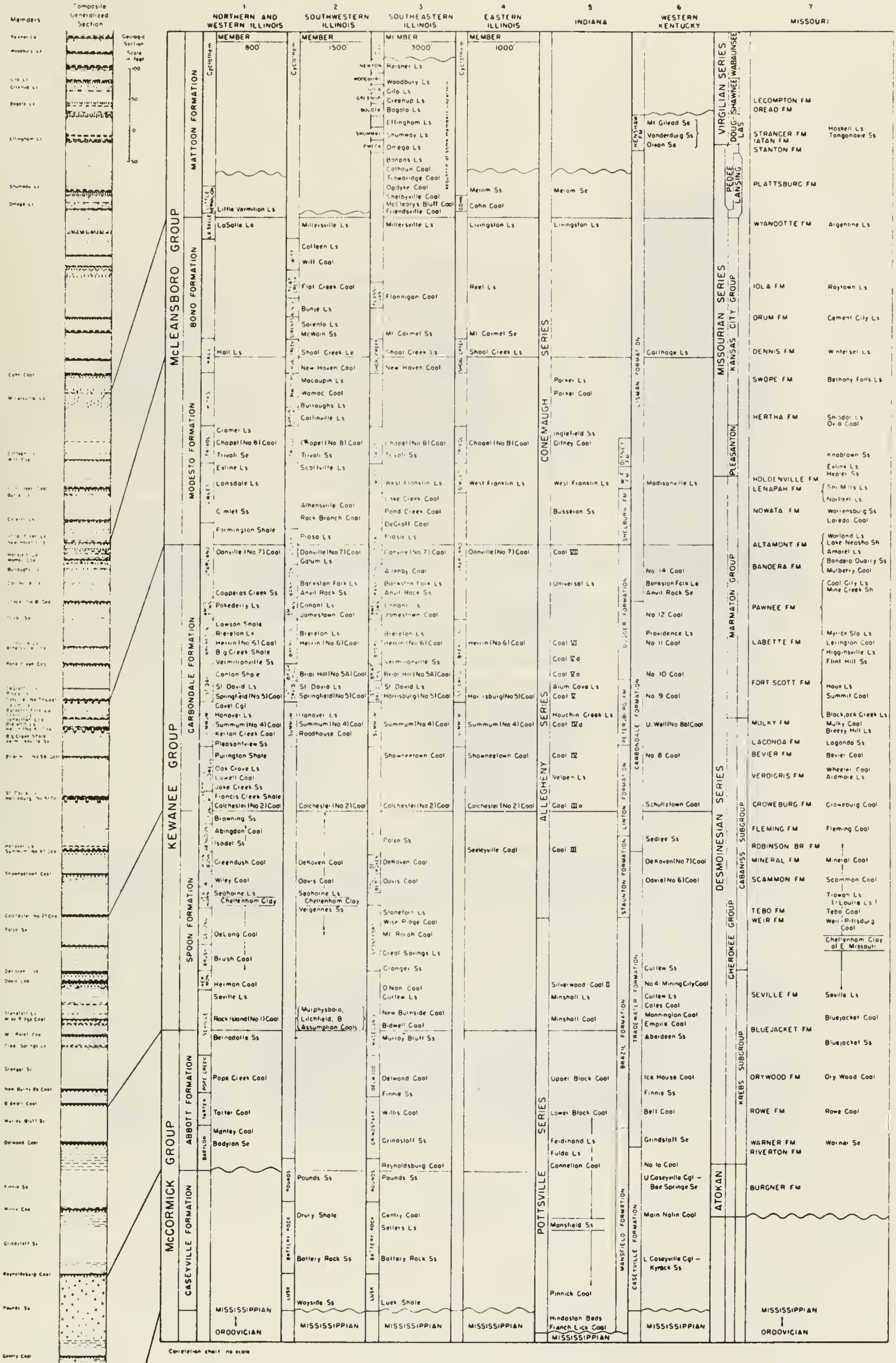
Plant debris from the rapidly growing swamp forests—leaves, twigs, branches, and logs—accumulated as thick mats of peat on the floors of the swamps. Normally, vegetable matter rapidly decays by oxidation, forming water, nitrogen, and carbon dioxide. However, the cover of swamp water, which was probably stagnant and low in oxygen, prevented the complete oxidation and decay of the peat deposits.

The periodic invasions of the Pennsylvanian sea across the coastal swamps killed the Pennsylvanian forests and initiated marine conditions of deposition. The peat deposits were buried by marine sediments. Following burial, the peat deposits were gradually transformed into coal by slow chemical and physical changes in which pressure (compaction by the enormous weight of overlying sedimentary layers), heat (also due to deep burial), and time were the most important factors. Water and volatile substances (nitrogen, hydrogen, and oxygen) were slowly driven off during the coalification process, and the peat deposits were changed into coal.

Coals have been classified by ranks that are based on the degree of coalification. The commonly recognized coals, in order of increasing rank, are (1) brown coal or lignite, (2) sub-bituminous, (3) bituminous, (4) semibituminous, (5) semianthracite, and (6) anthracite. Each increase in rank is characterized by larger amounts of fixed carbon and smaller amounts of oxygen and other volatiles. Hardness of coal also increases with increasing rank. All Illinois coals are classified as bituminous.

Underclays occur beneath most of the coals in Illinois. Because underclays are generally unstratified (unlayered), are leached to a bleached appearance, and generally contain plant roots, many geologists consider that they represent the ancient soils on which the coal-forming plants grew.

The exact origin of the carbonaceous black shales that occur above many coals is uncertain. The black shales probably are deposits formed under restricted marine (lagoonal) conditions during the initial part of the invasion cycle, when the region was partially closed off from the open sea. In any case, they were deposited in quiet-water areas where very fine, iron-rich muds and finely divided plant debris were washed in from the land. The high organic content of the black shales is also in part due to the carbonaceous remains of plants and animals that lived in the lagoons. Most of the fossils represent planktonic (floating) and nektonic (swimming) forms—not benthonic (bottom dwelling) forms. The depauperate (dwarf) fossil forms sometimes found in black shales formerly were thought to have been forms that were stunted by toxic conditions in the sulfide-rich, oxygen-deficient waters of the lagoons. However, study has shown that the "depauperate" fauna consists mostly of normal-size individuals of species that never grew any larger.



ROCK STRATIGRAPHIC AND CYCLICAL CLASSIFICATIONS OF THE PENNSYLVANIAN STRATA OF ILLINOIS

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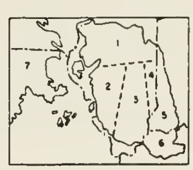
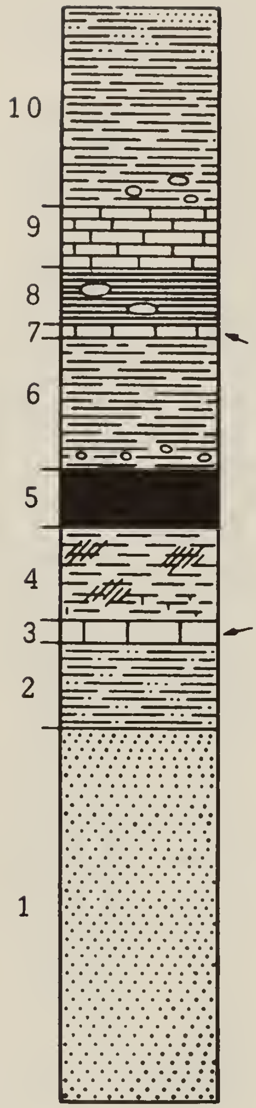


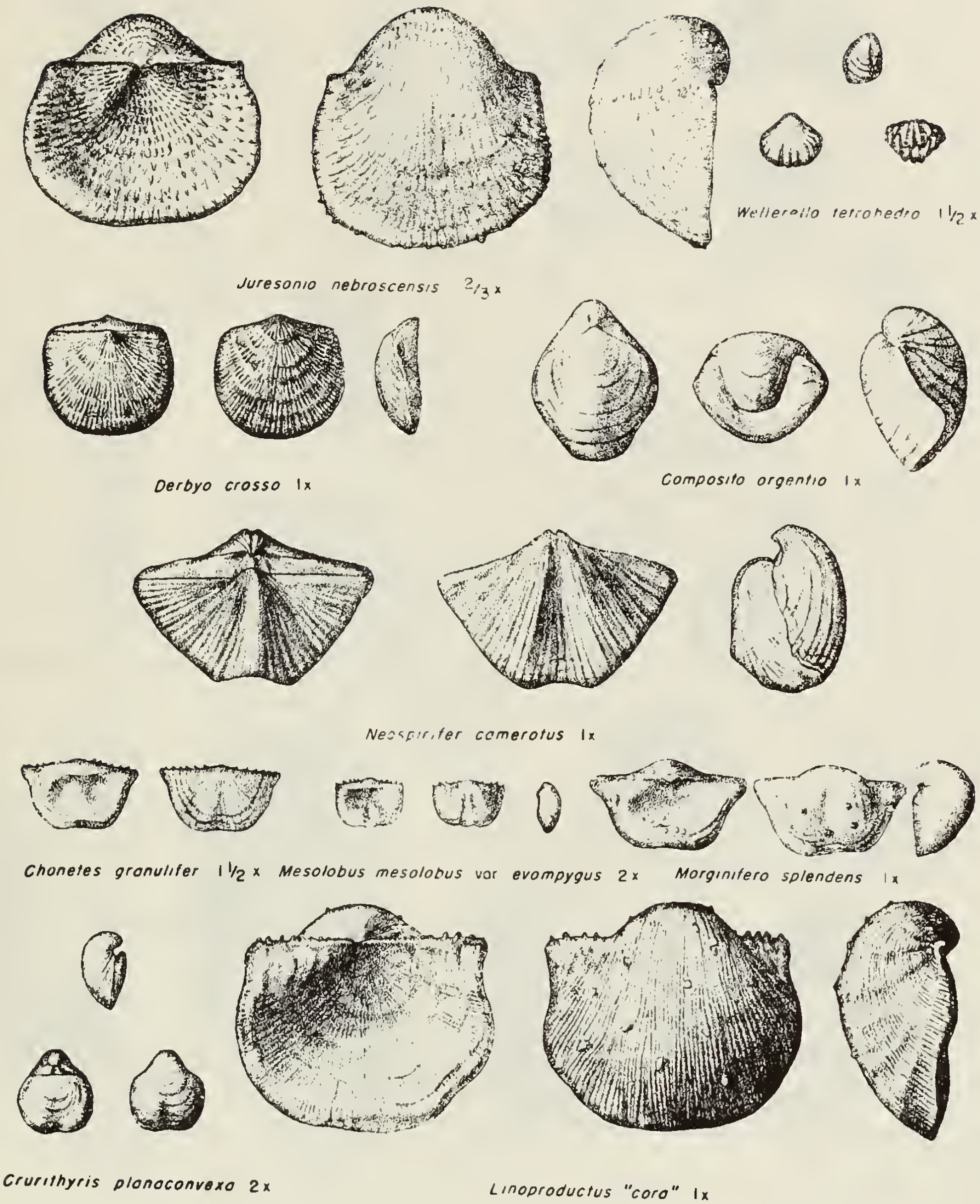
LOCATION MAP

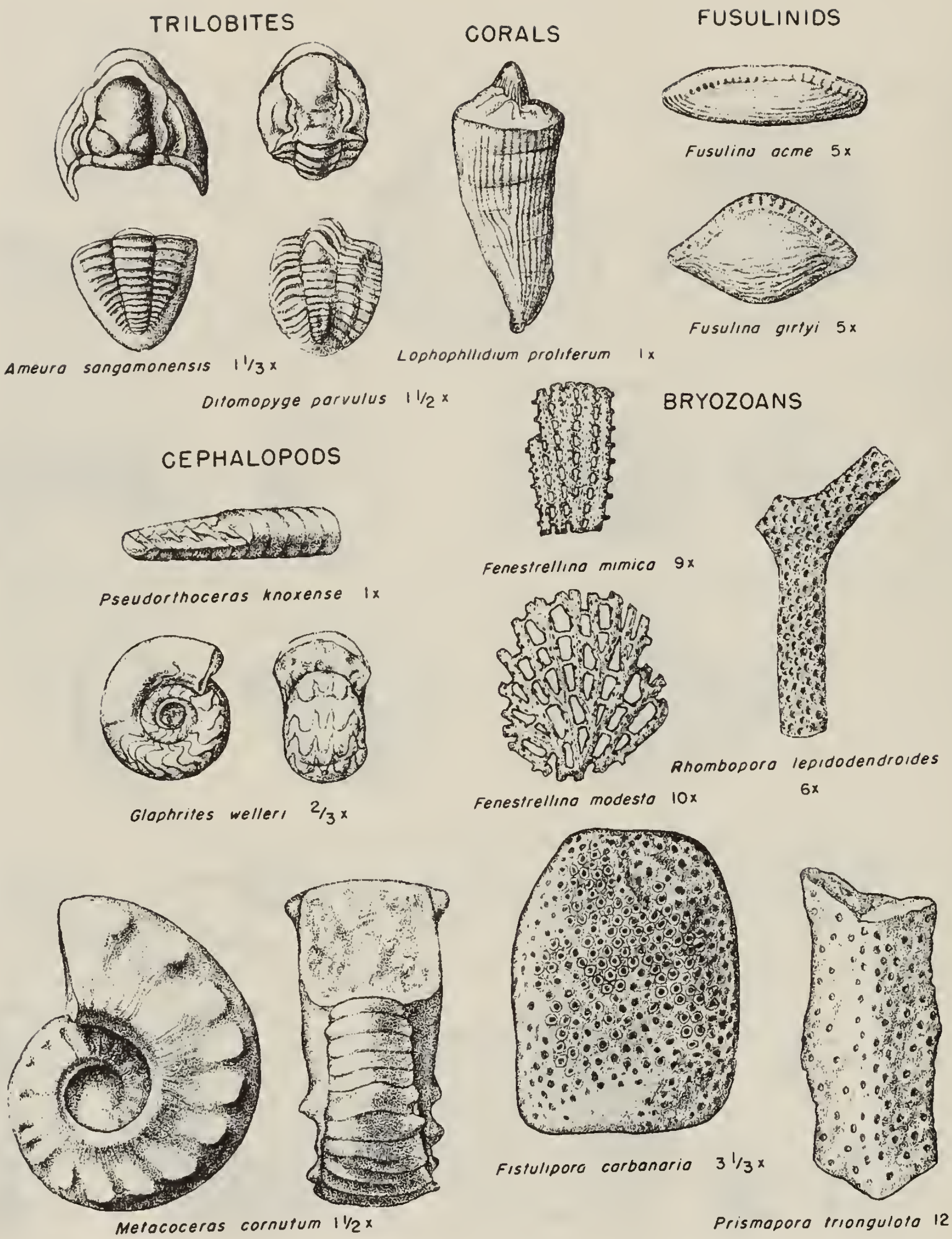


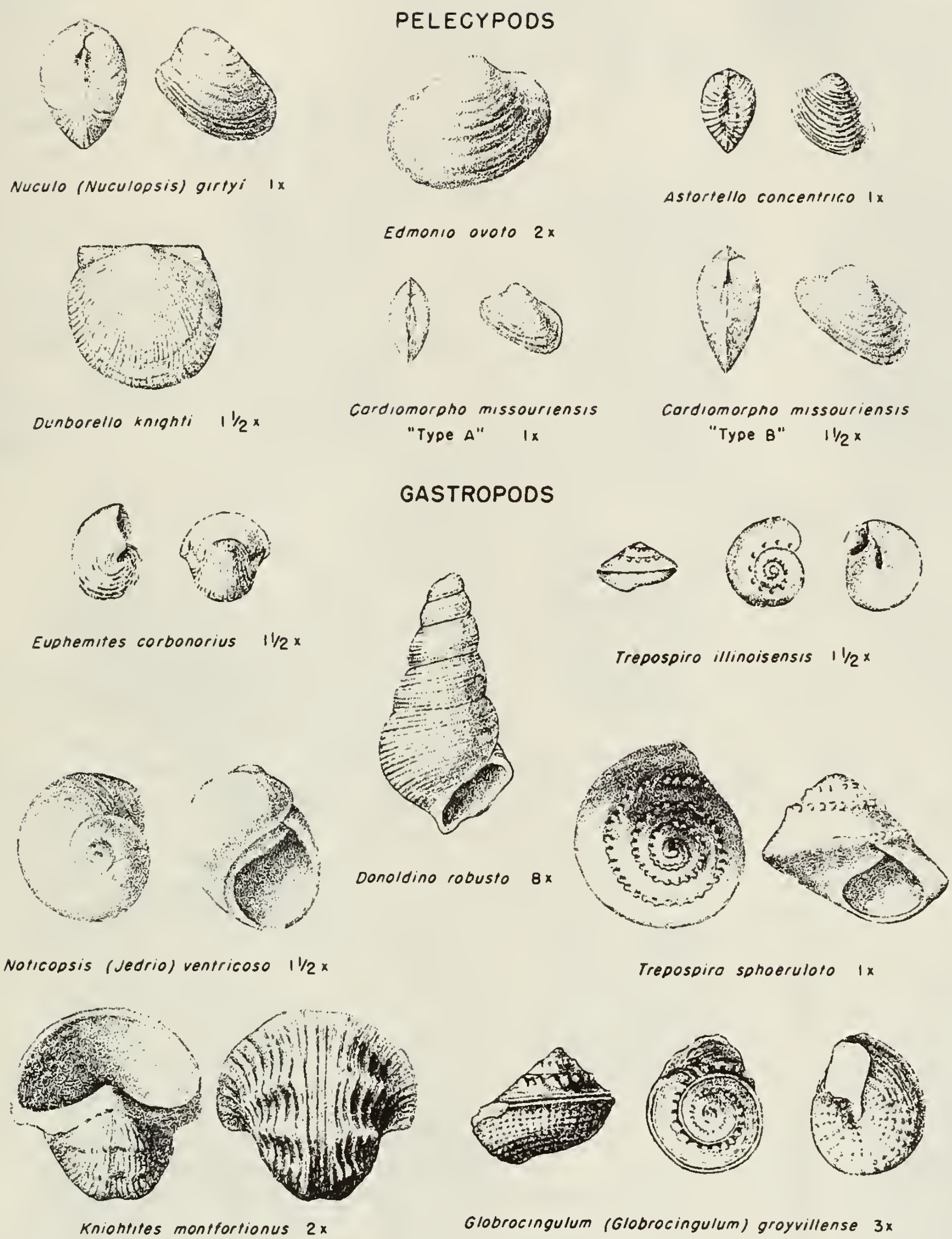
AN IDEALLY COMPLETE CYCLOTHEM

(Reprinted from Fig. 42, Bulletin No. 66, Geology and Mineral Resources of the Marseilles, Ottawa, and Streator Quadrangles, by H. B. Willman and J. Norman Payne)

BRACHIOPODS




TRILOBITES
CORALS
FUSULINIDS
Fusulina acme 5x
Fusulina girtyi 5x
Ameura sangamonensis 1 1/3 x
Lophophllidium proliferum 1x
Ditomopyge parvulus 1 1/2 x
BRYOZOANS
CEPHALOPODS
Fenestrellina mimica 9x
Pseudorthoceras knoxense 1x
Rhombopora lepidodendroides 6x
Fenestrellina modesta 10x
Glaphrites welleri 2/3 x
Fistulipora carbonaria 3 1/3 x
Metacoceras cornutum 1 1/2 x
Prismapora triangulata 12x


PELECYPODS
Nucula (Nuculopsis) girtyi 1x
Edmondia ovata 2x
Astartella concentrica 1x
Dunbarella knighti 1 1/2 x
Cardiomorpha missouriensis "Type A" 1x
Cardiomorpha missouriensis "Type B" 1 1/2 x
GASTROPODS
Euphemites carbonarius 1 1/2 x
Trepospira illinoisensis 1 1/2 x
Donaldina robusta 8x
Naticopsis (Jedria) ventricosa 1 1/2 x
Trepospira sphaerulata 1x
Knightites montfortianus 2x
Glabrocingulum (Glabrocingulum) grayvillense 3x

FOSSIL PLANTS, FRANCIS CREEK SHALE

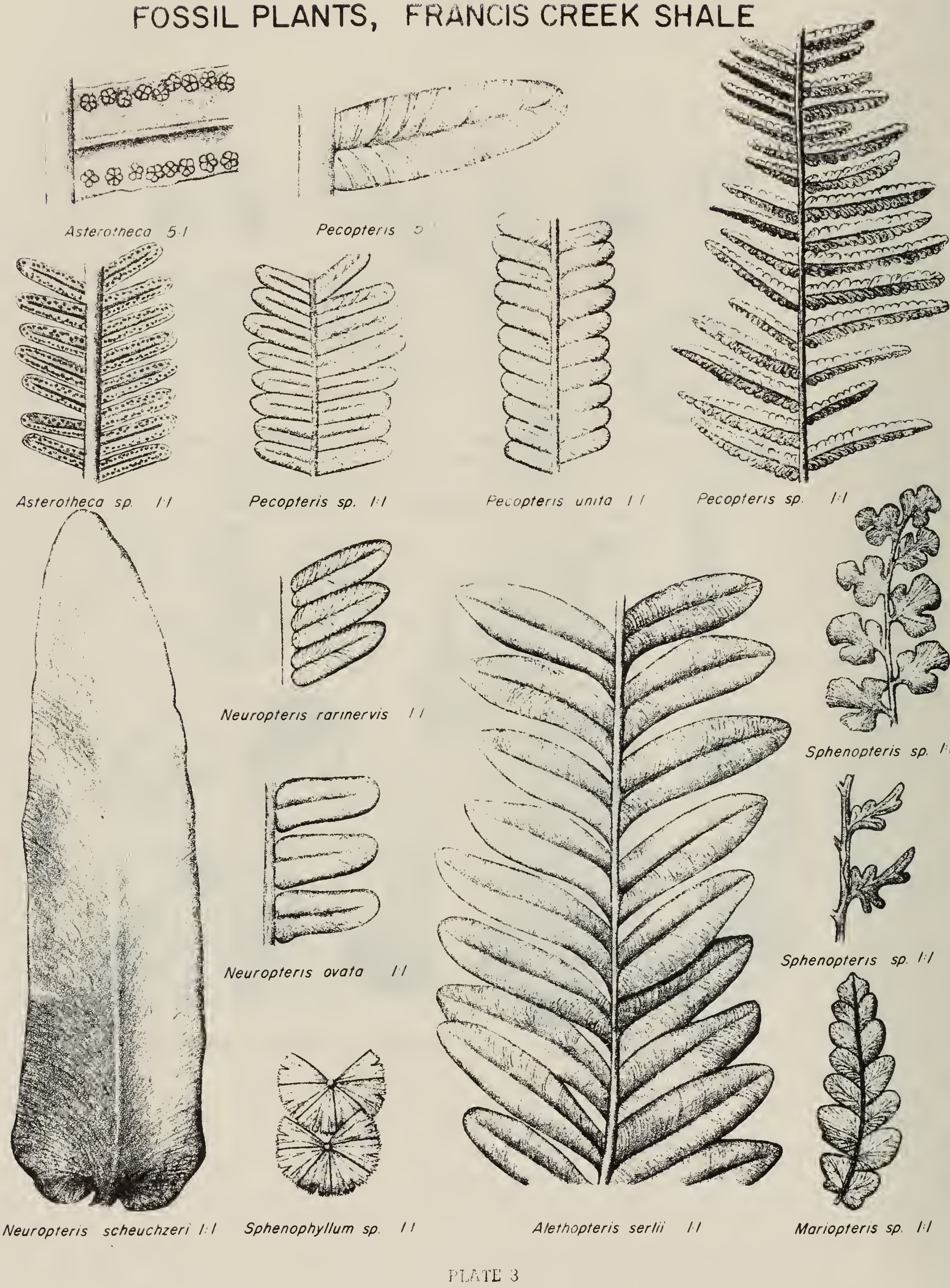
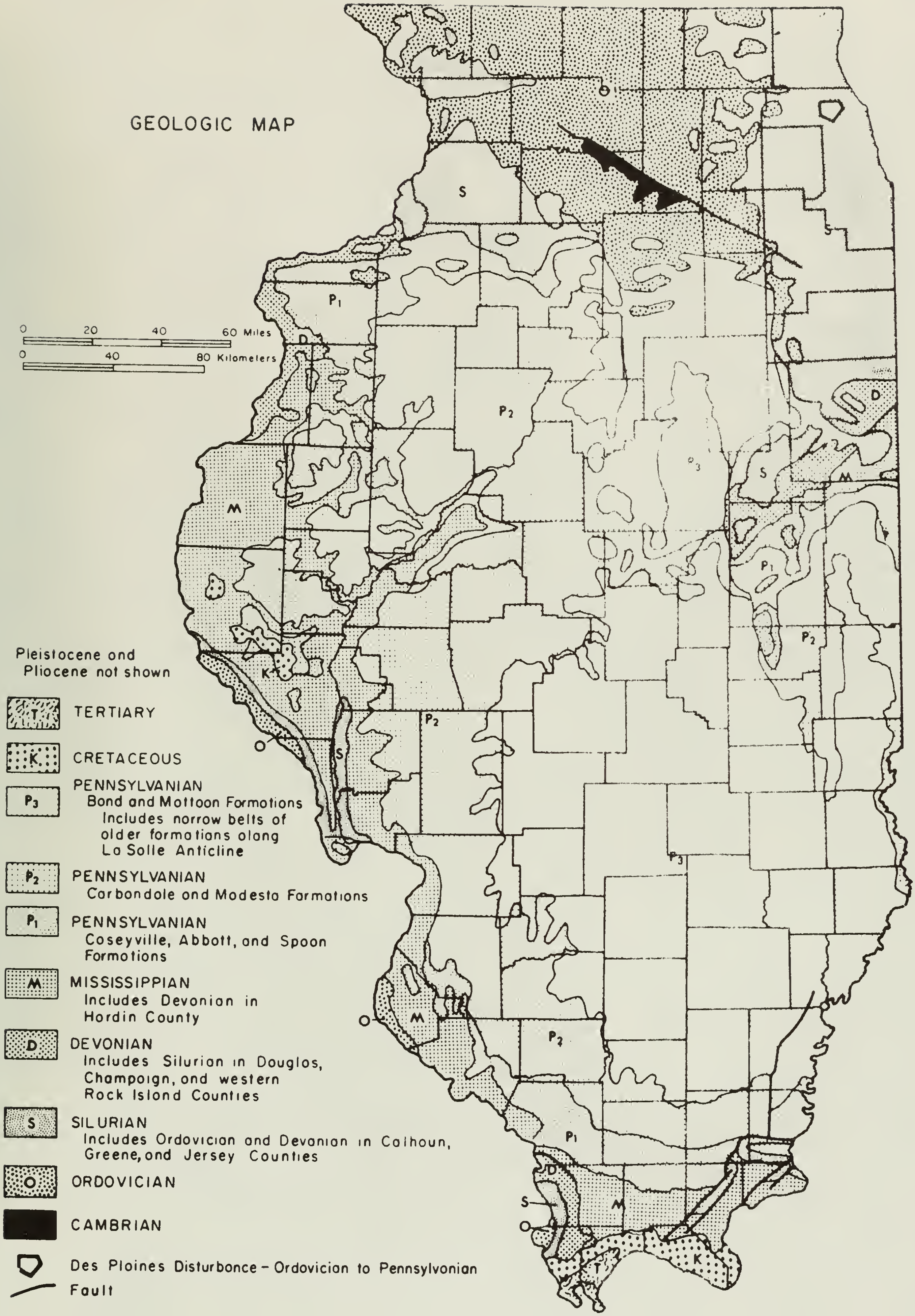


PLATE 3
(corrected)



GEOLOGIC MAP
0 20 40 60 Miles
0 40 80 Kilometers
Pleistocene and Pliocene not shown
T TERTIARY
K CRETACEOUS
P3 PENNSYLVANIAN
Bond and Mattoon Formations
Includes narrow belts of older formations along La Salle Anticline
P2 PENNSYLVANIAN
Carbondale and Modesto Formations
P1 PENNSYLVANIAN
Caseyville, Abbott, and Spoon Formations
M MISSISSIPPIAN
Includes Devonian in Hardin County
D DEVONIAN
Includes Silurian in Douglas, Champaign, and western Rock Island Counties
S SILURIAN
Includes Ordovician and Devonian in Calhoun, Greene, and Jersey Counties
O ORDOVICIAN
CAMBRIAN
Des Plaines Disturbance - Ordovician to Pennsylvanian
Fault

PLEISTOCENE GLACIATIONS IN ILLINOIS

Origin of the Glaciers

During the past million years or so, an interval of time called the Pleistocene Epoch, most of the northern hemisphere above the 50th parallel has been repeatedly covered by glacial ice. The cooling of the earth's surface, a prerequisite for glaciation, began at least 2 million years ago. On the basis of evidence found in subpolar oceans of the world (temperature-dependent fossils and oxygen-isotope ratios), a recent proposal has been made to recognize the beginning of the Pleistocene at 1.6 million years ago. Ice sheets formed in sub-arctic regions many times and spread outward until they covered the northern parts of Europe and North America. In North America, early studies of the glacial deposits led to the model that four glaciations could explain the observed distribution of glacial deposits. The deposits of a glaciation were separated from each other by the evidence of intervals of time during which soils formed on the land surface. In order of occurrence from the oldest to the youngest, they were given the names Nebraskan, Kansan, Illinoian, and Wisconsinan Stages of the Pleistocene Epoch. Work in the last 30 years has shown that there were more than four glaciations but the actual number and correlations at this time are not known. Estimates that are gaining credibility suggest that there may have been about 14 glaciations in the last one million years. In Illinois, estimates range from 4 to 8 based on buried soils and glacial deposits. For practical purposes, the previous four glacial stage model is functional, but we now know that the older stages are complex and probably contain more than one glaciation. Until we know more, all of the older glacial deposits, including the Nebraskan and Kansan will be classified as pre-Illinoian. The limits and times of the ice movement in Illinois are illustrated in the following pages by several figures.

The North American ice sheets developed when the mean annual temperature was perhaps 4° to 7°C (7° to 13°F) cooler than it is now and winter snows did not completely melt during the summers. Because the time of cooler conditions lasted tens of thousands of years, thick masses of snow and ice accumulated to form glaciers. As the ice thickened, the great weight of the ice and snow caused them to flow outward at their margins, often for hundreds of miles. As the ice sheets expanded, the areas in which snow accumulated probably also increased in extent.

Tongues of ice, called lobes, flowed southward from the Canadian centers near Hudson Bay and converged in the central lowland between the Appalachian and Rocky Mountains. There the glaciers made their farthest advances to the south. The sketch below shows several centers of flow, the general directions of flow from the centers, and the southern extent of glaciation. Because Illinois lies entirely in the central lowland, it has been invaded by glaciers from every center.

Effects of Glaciation

Pleistocene glaciers and the waters melting from them changed the landscapes they covered. The glaciers scraped and smeared the landforms they overrode, leveling and filling many of the minor valleys and even some of the larger ones. Moving ice carried colossal amounts of rock and earth, for much of what the glaciers wore off the ground was kneaded into the moving ice and carried along, often for hundreds of miles.

The continual floods released by melting ice entrenched new drainageways, deepened old ones, and then partly refilled both with sediments as great quantities of rock and earth were carried beyond the glacier fronts. According to some estimates, the amount of water drawn from the sea and changed into ice during a glaciation was enough to lower the sea level from 300 to 400 feet below present level. Consequently, the melting of a continental ice sheet provided a tremendous volume of water that eroded and transported sediments.

In most of Illinois, then, glacial and meltwater deposits buried the old rock-ribbed, low, hill-and-valley terrain and created the flatter landforms of our prairies. The mantle of soil material and the buried deposits of gravel, sand, and clay left by the glaciers over about 90 percent of the state have been of incalculable value to Illinois residents.

Glacial Deposits

The deposits of earth and rock materials moved by a glacier and deposited in the area once covered by the glacier are collectively called **drift**. Drift that is ice-laid is called **till**. Water-laid drift is called **outwash**.

Till is deposited when a glacier melts and the rock material it carries is dropped. Because this sediment is not moved much by water, a till is unsorted, containing particles of different sizes and compositions. It is also stratified (unlayered). A till may contain materials ranging in size from microscopic clay particles to large boulders. Most tills in Illinois are pebbly clays with only a few boulders. For descriptive purposes, a mixture of clay, silt, sand and boulders is called **diamicton**. This is a term used to describe a deposit that could be interpreted as till or a mass wasting product.

Tills may be deposited as **end moraines**, the arc-shaped ridges that pile up along the glacier edges where the flowing ice is melting as fast as it moves forward. Till also may be deposited as **ground moraines**, or **till plains**, which are gently undulating sheets deposited when the ice front melts back, or retreats. Deposits of till identify areas once covered by glaciers. Northeastern Illinois has many alternating ridges and plains, which are the succession of end moraines and till plains deposited by the Wisconsinan glacier.

Sorted and stratified sediment deposited by water melting from the glacier is called **outwash**. Outwash is bedded, or layered, because the flow of water that deposited it varied in gradient, volume, velocity, and direction. As a meltwater stream washes the rock materials along, it sorts them by size—the fine sands, silts, and clays are carried farther downstream than the coarser gravels and cobbles. Typical Pleistocene outwash in Illinois is in multilayered beds of clays, silts, sands, and gravels that look much like modern stream deposits in some places. In general, outwash tends to be coarser and less weathered, and alluvium is most often finer than medium sand and contains variable amounts of weathered material.

Outwash deposits are found not only in the area covered by the ice field but sometimes far beyond it. Meltwater streams ran off the top of the glacier, in crevices in the ice, and under the ice. In some places, the cobble-gravel-sand filling of the bed of a stream that flowed in the ice is preserved as a sinuous ridge called an **esker**. Some eskers in Illinois are made up of sandy to silty deposits and contain mass wasted diamicton material. Cone-shaped mounds of coarse outwash, called **kames**, were formed where meltwater plunged through crevasses in the ice or into ponds on the glacier.

The finest outwash sediments, the clays and silts, formed bedded deposits in the ponds and lakes that filled glacier-dammed stream valleys, the sags of the till plains, and some low, moraine-diked till plains. Meltwater streams that entered a lake rapidly lost speed and also quickly dropped the sands and gravels they carried, forming deltas at the edge of the lake. Very fine sand and silts were commonly redistributed on the lake bottom by wind-generated currents, and the clays, which stayed in suspension longest, slowly settled out and accumulated with them.

Along the ice front, meltwater ran off in innumerable shifting and short-lived streams that laid down a broad, flat blanket of outwash that formed an **outwash plain**. Outwash was also carried away from the glacier in valleys cut by floods of meltwater. The Mississippi, Illinois, and Ohio Rivers occupy valleys that were major channels for meltwaters and were greatly widened and deepened during times of the greatest meltwater floods. When the floods waned, these valleys were partly filled with outwash far beyond the ice margins. Such outwash deposits, largely sand and gravel, are known as **valley trains**. Valley train deposits may be both extensive and thick. For instance, the long valley train of the Mississippi Valley is locally as much as 200 feet thick.

Loess, Eolian Sand and Soils

One of the most widespread sediments resulting from glaciation was carried not by ice or water but by wind. **Loess** is the name given to windblown deposits dominated by silt. Most of the silt was derived from wind erosion of the valley trains. Wind action also sorted out **eolian sand** which commonly formed **sand dunes** on the valley trains or on the adjacent uplands. In places, sand dunes have migrated up to 10 miles away from the principle source of sand. Flat areas between dunes are generally underlain by eolian **sheet sand** that is commonly reworked by water action. On uplands along the major valley trains, loess and eolian sand are commonly interbedded. With increasing distance from the valleys, the eolian sand pinches out, often within one mile.

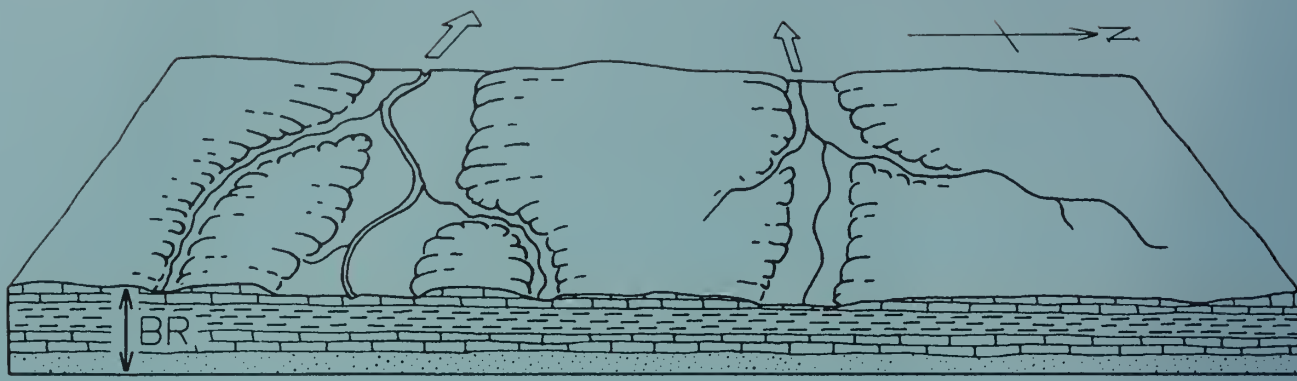
Eolian deposition occurred when certain climatic conditions were met, probably in a seasonal pattern. Deposition could have occurred in the fall, winter or spring season when low precipitation rates and low temperatures caused meltwater floods to abate, exposing the surfaces of the valley trains and permitting them to dry out. During Pleistocene time, as now, west winds prevailed, and the loess deposits are thickest on the east sides of the source valleys. The loess thins rapidly away from the valleys but extends over almost all the state.

Each Pleistocene glaciation was followed by an interglacial stage that began when the climate warmed enough to melt the glaciers and their snowfields. During these warmer intervals, when the climate was similar to that of today, drift and loess surfaces were exposed to weather and the activities of living things. Consequently, over most of the glaciated terrain, soils developed on the Pleistocene deposits and altered their composition, color, and texture. Such soils were generally destroyed by later glacial advances, but some were buried. Those that survive serve as "key beds," or stratigraphic markers, and are evidence of the passage of a long interval of time.

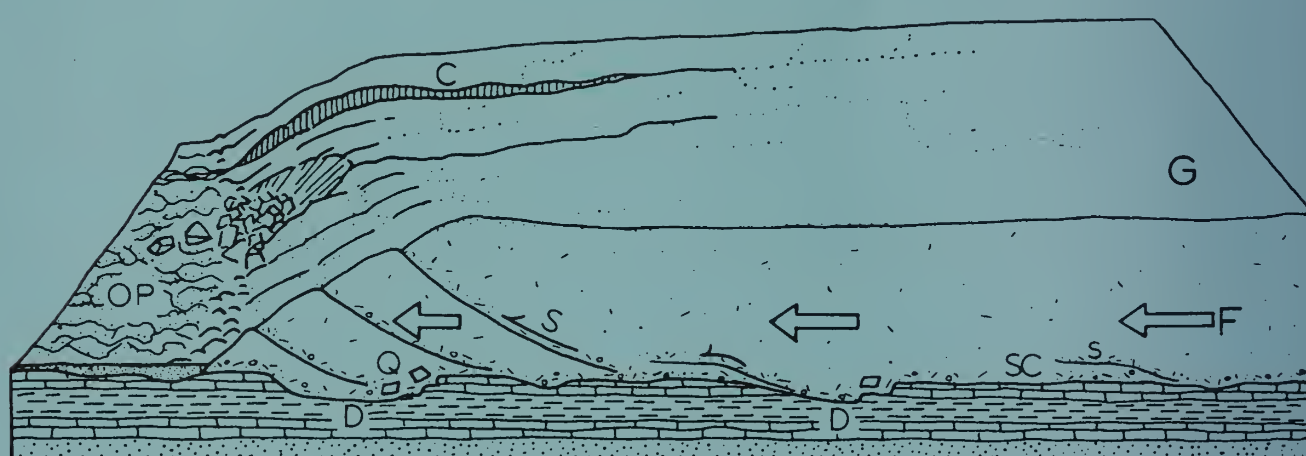
Glaciation in a Small Illinois Region

The following diagrams show how a continental ice sheet might have looked at various stages as it moved across a small region in Illinois. They illustrate how it could change the old terrain and create a landscape like the one we live on. To visualize how these glaciers looked, geologists study the landforms and materials left in the glaciated regions and also the present-day mountain glaciers and polar ice caps.

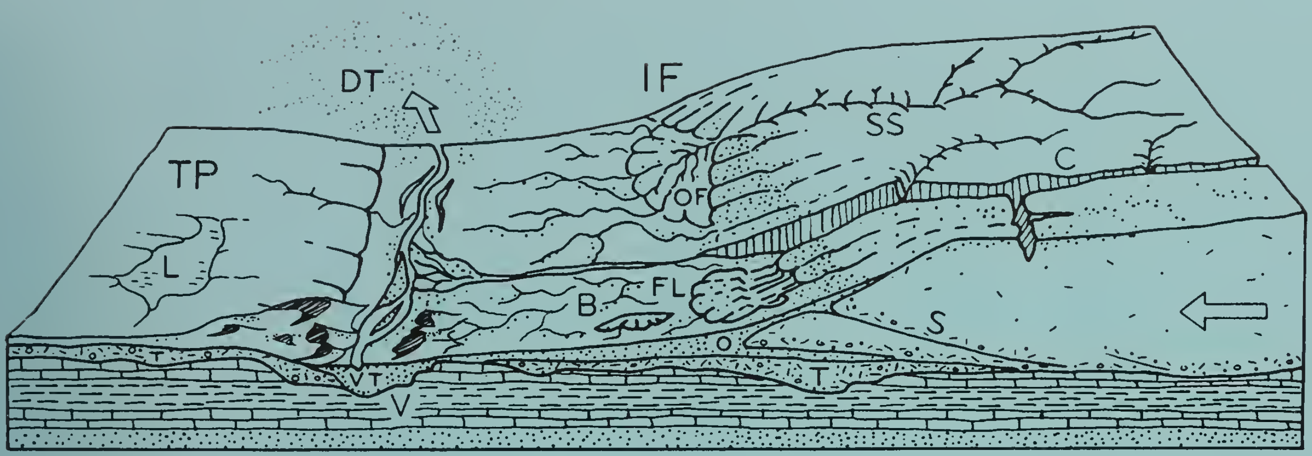
The block of land in the diagrams is several miles wide and about 10 miles long. The vertical scale is exaggerated—layers of material are drawn thicker and landforms higher than they ought to be so that they can be easily seen.



1. **The Region Before Glaciation** — Like most of Illinois, the region illustrated is underlain by almost flat-lying beds of sedimentary rocks—layers of sandstone ( ), limestone ( ), and shale ( ). Millions of years of erosion have planed down the bedrock (BR), creating a terrain of low uplands and shallow valleys. A residual soil weathered from local rock debris covers the area but is too thin to be shown in the drawing. The streams illustrated here flow westward and the one on the right flows into the other at a point beyond the diagram.



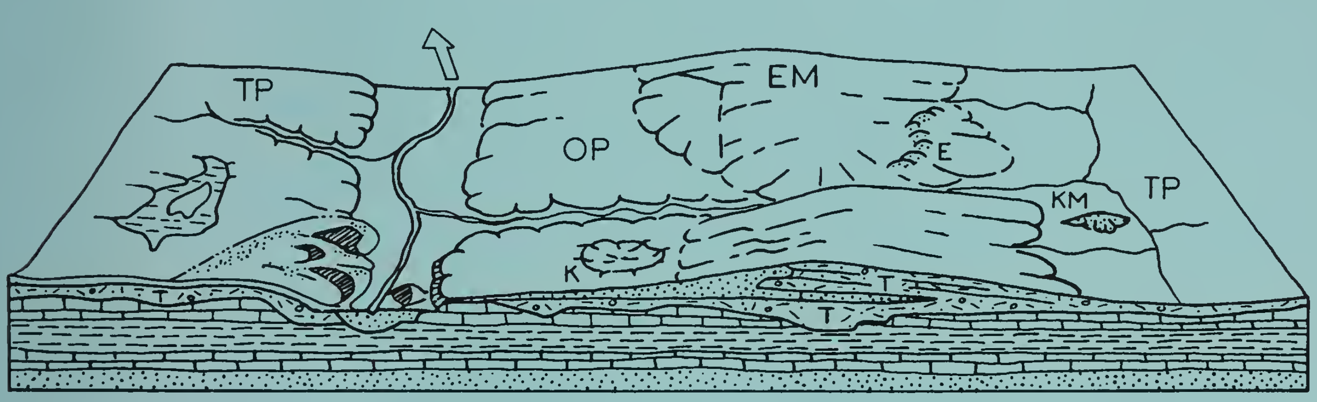
2. **The Glacier Advances Southward** — As the Glacier (G) spreads out from its ice snowfield accumulation center, it scours (SC) the soil and rock surface and quarries (Q)—pushes and plucks up—chunks of bedrock. The materials are mixed into the ice and make up the glacier's "load." Where roughnesses in the terrain slow or stop flow (F), the ice "current" slides up over the blocked ice on innumerable shear planes (S). Shearing mixes the load very thoroughly. As the glacier spreads, long cracks called "crevasses" (C) open parallel to the direction of ice flow. The glacier melts as it flows forward, and its meltwater erodes the terrain in front of the ice, deepening (D) some old valleys before ice covers them. Meltwater washes away some of the load freed by melting and deposits it on the outwash plain (OP). The advancing glacier overrides its outwash and in places scours much of it up again. The glacier may be 5000 or so feet thick, and tapers to the margin, which was probably in the range of several hundred feet above the old terrain. The ice front advances perhaps as much as a third of a mile per year.



3. **The Glacier Deposits an End Moraine** — After the glacier advances across the area, the climate warms and the ice begins to melt as fast as it advances. The ice front (IF) is now stationary, or fluctuating in a narrow area, and the glacier is depositing an end moraine.

As the top of the glacier melts, some of the sediment that is mixed in the ice accumulates on top of the glacier. Some is carried by meltwater onto the sloping ice front (IF) and out onto the plain beyond. Some of the debris slips down the ice front in a mudflow (FL). Meltwater runs through the ice in a crevasse (C). A supraglacial stream (SS) drains the top of the ice, forming an outwash fan (OF). Moving ice has overridden an immobile part of the front on a shear plane (S). All but the top of a block of ice (B) is buried by outwash (O).

Sediment from the melted ice of the previous advance (figure 2) remains as a till layer (T), part of which forms the till plain (TP). A shallow, marshy lake (L) fills a low place in the plain. Although largely filled with drift, the valley (V) remains a low spot in the terrain. As soon as the ice cover melts, meltwater drains down the valley, cutting it deeper. Later, outwash partly refills the valley: the outwash deposit is called a valley train (VT). Wind blows dust (DT) off the dry floodplain. The dust will form a loess deposit when it settles. Sand dunes (D) form on the south and east sides of streams.



4. **The Region after Glaciation** — As the climate warms further, the whole ice sheet melts, and glaciation ends. The end moraine (EM) is a low, broad ridge between the outwash plain (OP) and till plains (TP). Run-off from rains cuts stream valleys into its slopes. A stream goes through the end moraine along the channel cut by the meltwater that ran out of the crevasse in the glacier.

Slopewash and vegetation are filling the shallow lake. The collapse of outwash into the cavity left by the ice block's melting has made a kettle (K). The outwash that filled a tunnel draining under the glacier is preserved in an esker (E). The hill of outwash left where meltwater dumped sand and gravel into a crevasse or other depression in the glacier or at its edge is a kame (KM). A few feet of loess covers the entire area but cannot be shown at this scale.

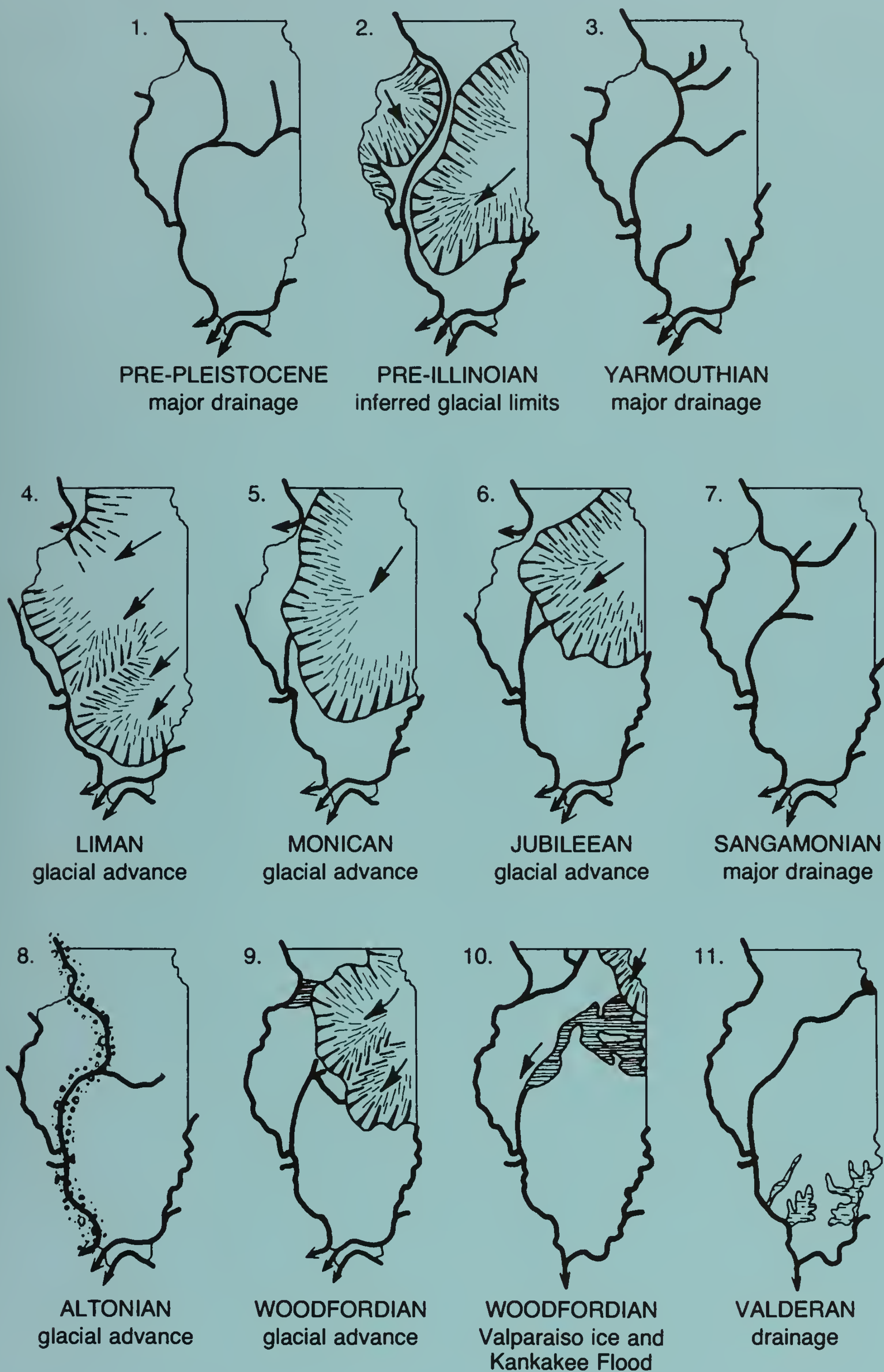
TIME TABLE OF PLEISTOCENE GLACIATION

		STAGE		SUBSTAGE	NATURE OF DEPOSITS	SPECIAL FEATURES
QUATERNARY		HOLOCENE (interglacial)		Years Before Present	Soil, youthful profile of weathering, lake and river deposits, dunes, peat	
				10,000		
	Pleistocene	WISCONSINAN (glacial)	late	Valderan	Outwash, lake deposits	Outwash along Mississippi Valley
				11,000		
				Twocreekan	Peat and alluvium	Ice withdrawal, erosion
				12,500		
				Woodfordian	Drift, loess, dunes, lake deposits	Glaciation; building of many moraines as far south as Shelbyville; extensive valley trains, outwash plains, and lakes
				25,000		
			mid	Farmdalian	Soil, silt, and peat	Ice withdrawal, weathering, and erosion
				28,000		
			early	Altonian	Drift, loess	Glaciation in Great Lakes area, valley trains along major rivers
				75,000		
		SANGAMONIAN (interglacial)			Soil, mature profile of weathering	Important stratigraphic marker
				125,000		
		ILLINOIAN (glacial)		Jubileean	Drift, loess, outwash	Glaciers from northeast at maximum reached Mississippi River and nearly to southern tip of Illinois
				Monican	Drift, loess, outwash	
				Liman	Drift, loess, outwash	
				300,000?		
		YARMOUTHIAN (interglacial)			Soil, mature profile of weathering	Important stratigraphic marker
				500,000?		
		Pre-Illinoian: KANSAN* (glacial)			Drift, loess	Glaciers from northeast and northwest covered much of state
				700,000?		
		Pre-Illinoian: AFTONIAN* (interglacial)			Soil, mature profile of weathering	(hypothetical)
				900,000?		
		Pre-Illinoian: NEBRASKAN* (glacial)			Drift (little known)	Glaciers from northwest invaded western Illinois
				1,600,000 or more		

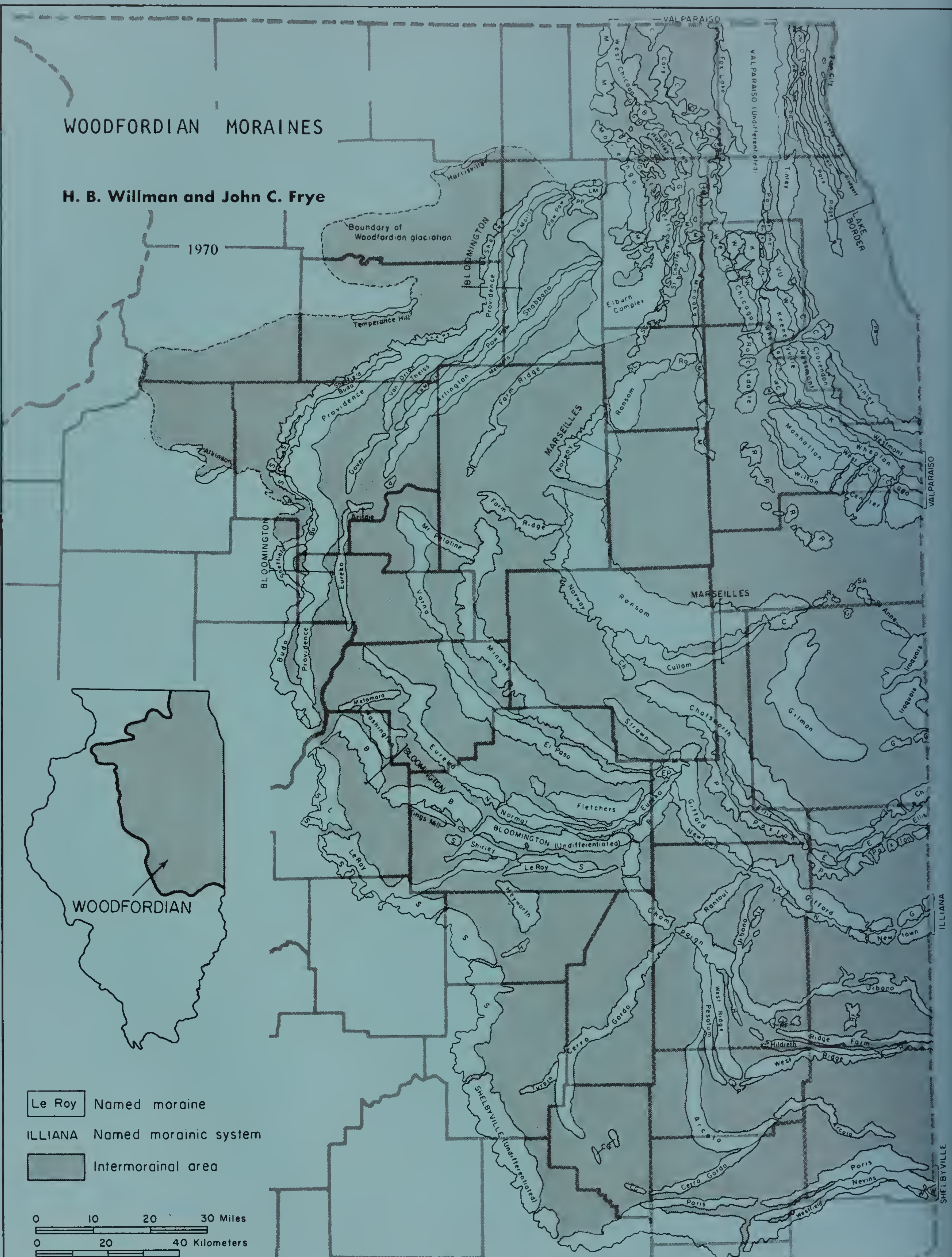
*Old oversimplified concepts, now known to represent a series of glacial cycles.

(Illinois State Geological Survey, 1973)

SEQUENCE OF GLACIATIONS AND INTERGLACIAL DRAINAGE IN ILLINOIS



(Modified from Willman and Frye, "Pleistocene Stratigraphy of Illinois," ISGS Bull. 94, fig. 5, 1970.)


WOODFORDIAN MORAINES
H. B. Willman and John C. Frye
1970
Boundary of Woodfordian glaciation
VALPARAISO
VALPARAISO (Undifferentiated)
LAKE BORDER
BLOOMINGTON
MARSEILLES
BLOOMINGTON (Undifferentiated)
SHELBYVILLE (Undifferentiated)
ILLIANA
SHELBYVILLE
Harrisville
Temperance Hill
Atkinson
Providence
Shabbona
Farm Ridge
Dover
Mt Palatine
Eureka
Varna
Minonk
Ransom
Norway
Cullom
Chatsworth
Strawn
El Paso
Fletchers
Normal
Shirley
Le Roy
Heyworth
Metamora
Champaign
Rantoul
Urbana
West Ridge
Pesotum
Cerro Gordo
Arcola
Paris
Nevins
Westfield
Hildreth
Gilman
Iroquois
Manhattan
Wilton
Wheaton
Westmont
Tinley
Elburn Complex
Chicago
Rockdale
Newtown
Gifford
WOODFORDIAN
Le Roy Named moraine
ILLIANA Named morainic system
Intermorainal area
0 10 20 30 Miles
0 20 40 Kilometers

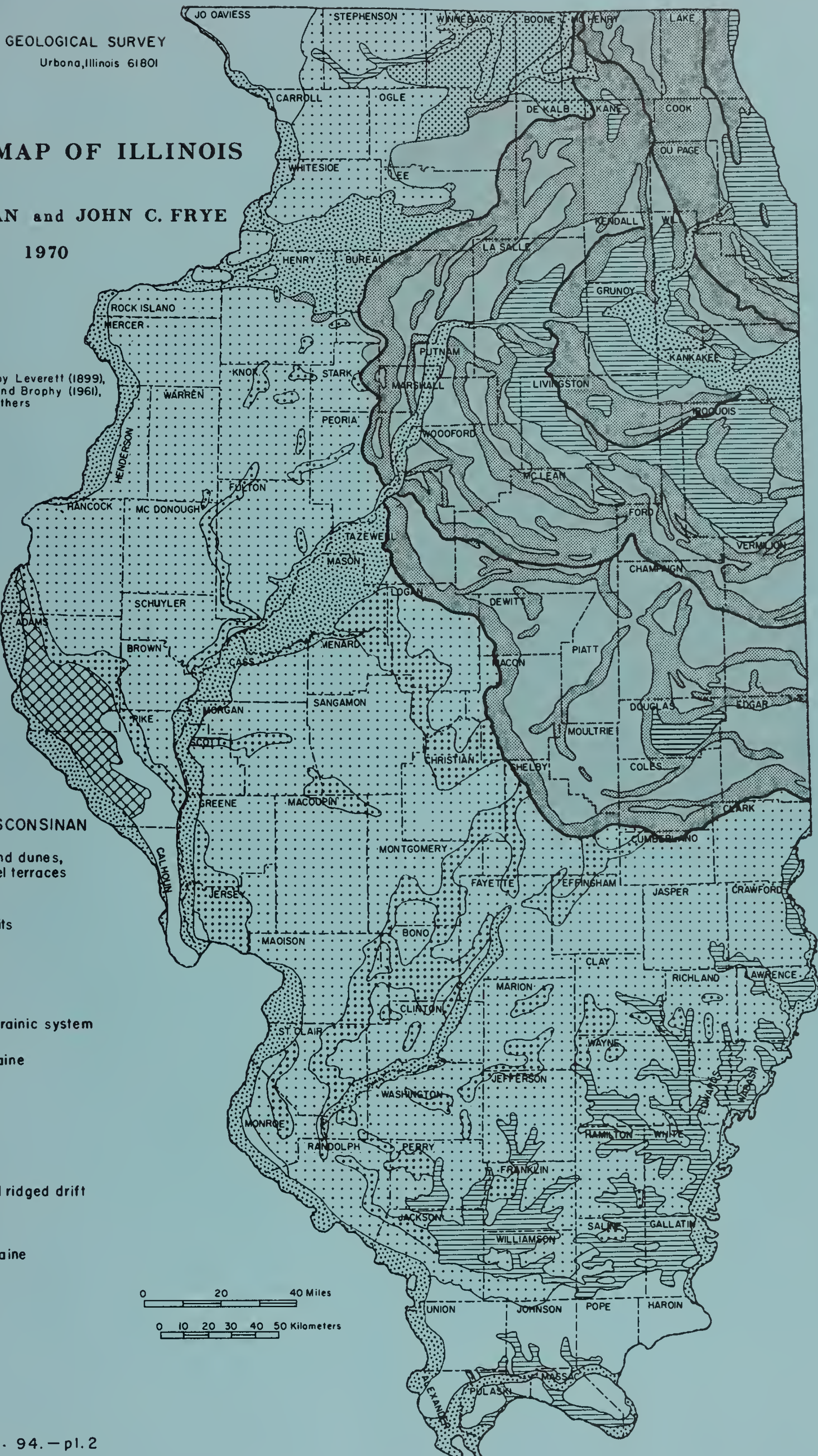
ILLINOIS STATE GEOLOGICAL SURVEY
John C. Frye, Chief Urbana, Illinois 61801

GLACIAL MAP OF ILLINOIS

H.B. WILLMAN and JOHN C. FRYE

1970

Modified from maps by Leverett (1899), Ekblow (1959), Leighton and Brophy (1961), Willman et al. (1967), and others



EXPLANATION

HOLOCENE AND WISCONSINAN

Alluvium, sand dunes, and gravel terraces

WISCONSINAN

Lake deposits

WOODFORDIAN

Moraine

Front of morainic system

Groundmoraine

ALTONIAN

Till plain

ILLINOIAN

Moraine and ridged drift

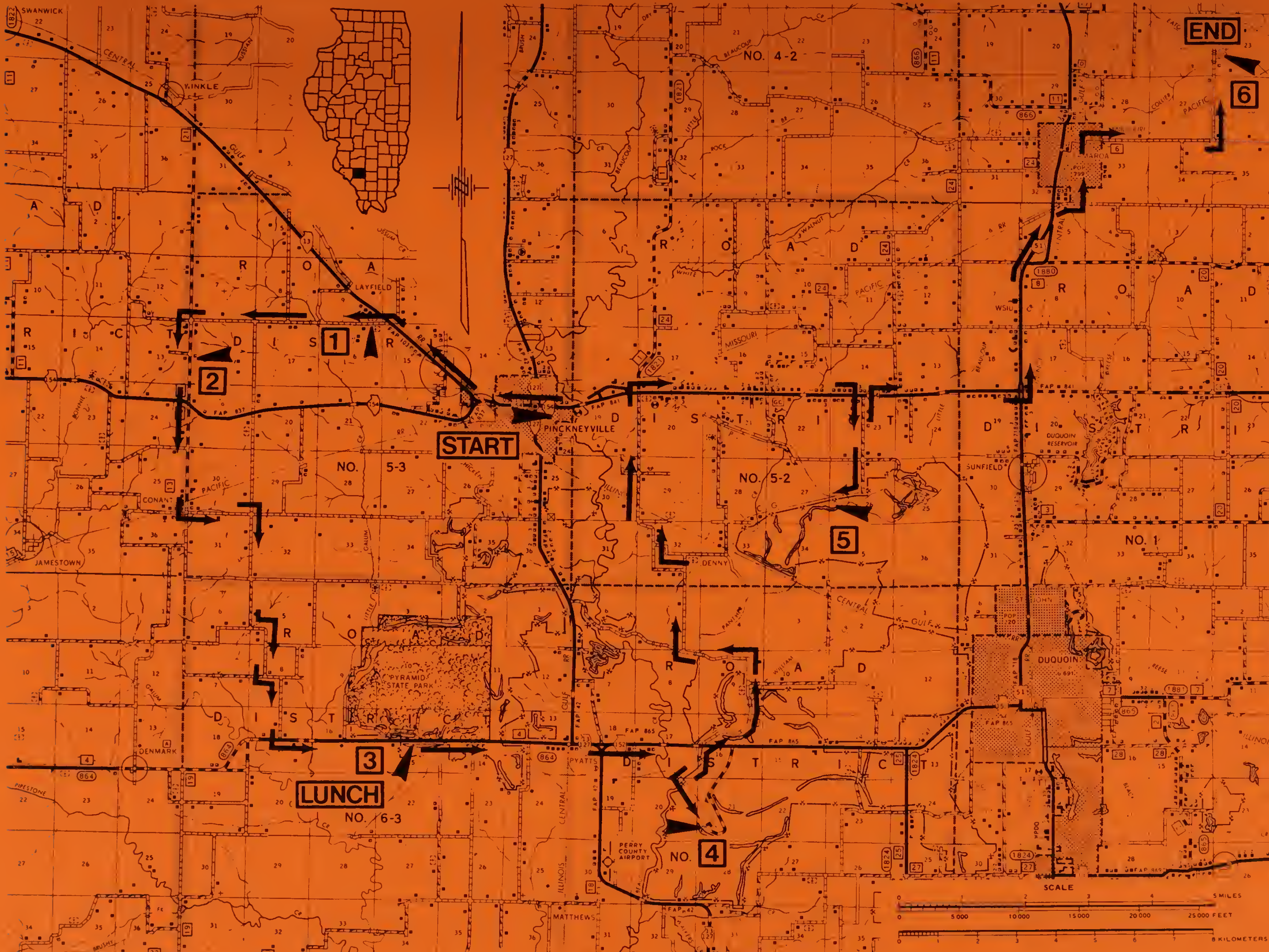
Groundmoraine

KANSAN

Till plain

DRIFTLESS

Modified from Bull. 94.—pl. 2


START
LUNCH
END
1
2
3
4
5
6
PINCKNEYVILLE
DUQUOIN
PYRAMID STATE PARK
PERRY COUNTY AIRPORT
DUQUOIN RESERVOIR
SWANWICK
WINKLE
LAYFIELD
CONANT
JAMESTOWN
DENMARK
PYATTS
MATTHEWS
DENNY
SUNFIELD
WSIU
NO. 4-2
NO. 5-3
NO. 5-2
NO. 6-3
NO. 4
NO. 1
ILLINOIS CENTRAL GULF RR
MISSOURI PACIFIC
FAP 42
FAP 865
FAP 841
FAP 837
SCALE
5 MILES
25 000 FEET
8 KILOMETERS